R Series, Vol. V, No. 2 December 1946

PALESTINE JOURNAL OF BOTANY

Rehovot Series

(formerly the Palestine Journal of Botany and Horticultural Science)

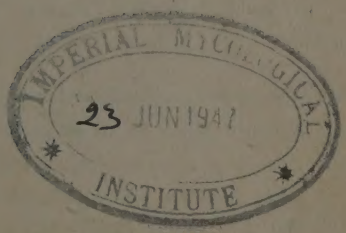
EDITED BY

H. R. OPPENHEIMER and I. REICHERT

of the Agricultural Research Station, Rehovot, Palestine

EDITORIAL SECRETARY:

J. PALTI



REHOVOT

PALESTINE JOURNAL OF BOTANY

appears in two series

THE REHOVOT SERIES (R)

is edited by H. R. OPPENHEIMER and I. REICHERT, of the Agricultural Research Station, Rehovot, Palestine. Each volume of this series is scheduled to comprise two issues per year, totalling 200—300 pages.

THE JERUSALEM SERIES (J)

is edited by the Staff of the Department of Botany of the Hebrew University, Jerusalem. Each volume of this series is scheduled to comprise four issues per year, totalling 300—400 pages.

Subscriptions are payable in advance by crossed cheque or postal order
The subscription price is

40 s. (£2.—.—) per volume, post free, for both series
24 s. (£1. 4.—) per volume, post free, for JERUSALEM SERIES only
18 s. (£0.18—) per volume, post free, for REHOVOT SERIES only

Subscriptions and correspondence concerning editorial or business matters should be addressed
for the JERUSALEM SERIES: Palestine Journal of Botany, P.O.B. 620, Jerusalem, Palestine,
for the REHOVOT SERIES: Palestine Journal of Botany, P.O.B. 15, Rehovot, Palestine.

Subscriptions or correspondence for both series of the Palestine Journal of Botany may be sent to either of the above addresses.

Back volumes of REHOVOT SERIES are obtainable at the following prices:

Vols. I, II and III at 15 s. (£0.15.—) each
Vol. IV at 18 s. (£0.18.—).

M. Shoham's Press, Tel-Aviv, Tel. 2239

PALESTINE

JOURNAL OF BOTANY

Vol. V, No. 2 *Rehovot Series* **December 1946**

CONTENTS

The development of downy and powdery mildew of cucumbers as related to dew and other environmental factors
By S. Duvdevani, I. Reichert and J. Palti 127

Diplodia natalensis, its occurrence on flowers, button and stem-end of Shamouti orange, and its relation to stem-and rot and fruit drop. By G. Minz 152

Bacterial rot of Avocado fruit.
By Zaphrira Elazari-Volcani 169

Powdery mildew on the leaves of *Dodonaea viscosa* Linn.
By Temira Volcani 181

Potato blight control in Palestine.
By F. Littauer, J. Palti and S. Moeller 186

Rust and Chocolate spot of broad beans in Palestine.
By I. Reichert and J. Palti 202

Field trials for the control of downy and powdery mildew of cucumbers. II. The comparative efficacy of copper and sulphur fungicides. By I. Reichert, J. Palti and S. Moeller 214

On a method of fiixing and measuring relative humidity in small closed containers. By I. Wahl 231

Dirinia ceratoniae in Palestine.
By I. Reichert and Z. Avisohar-Herchenson 239

The distribution of *Dirina ceratoniae*.
By I. Reichert 247

NOTES:

Preliminary trials on the prevention of blossom drop of tomatoes by a hormone spray.
By I. Reichert, S. Moeller and J. Palti 255

Downy mildew on cauliflower curds.
By Matilda Chorin 258

The powdery mildews of potatoes in Palestine.
By Matilda Chorin 259

Sclerotium bataticola Taubenhaus as causal agent of a rot of Shamouti oranges. By F. Littauer and J. Gutter 261

OBITUARY:

Olga Falck. By R. Falck 263

Abstracts in Hebrew ט־טו

THE DEVELOPMENT OF DOWNY AND POWDERY MILDEW OF CUCUMBERS AS RELATED TO DEW AND OTHER ENVIRONMENTAL FACTORS

By

S. DUVDEVANI,

Dew Research Station, Pardess Hanna Agricultural School, Karkur

I. REICHERT AND J. PALTI,

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

	Page
I. INTRODUCTION	127
II. METHODS	128
III. STANDARD METEOROLOGICAL RECORDS AND THEIR VALIDITY IN THE FIELD	133
IV. EFFECT OF DEW ON DEVELOPMENT OF DOWNY AND POWDERY MILDEW OF CUCUMBERS	134
V. ENVIRONMENTAL CONDITIONS CONDUCIVE TO THE OUTBREAK OF DOWNY MILDEW OF CUCUMBERS IN PALESTINE	140
VI. DISCUSSION	146
VII. SUMMARY	149
REFERENCES	151

I. INTRODUCTION

The diseases most prevalent on cucumbers in Palestine are powdery mildew (*Erysiphe cichoracearum* DC.) and downy mildew (*Pseudoperonospora cubensis* Berk. et Curt). The period of cucumber cultivation in the country extends from spring to autumn and during this period climatic conditions differ from those in other countries growing outdoor crops of cucumbers mainly by the absence of summer rains. The importance of the latter for the development of downy mildew on cucumbers has been observed in various countries (6), but DORAN (2) has pointed out that dew may serve as well as rain for most stages in the life of the downy mildew fungus. The essential rôle played by dew in the development in Palestine of another downy mildew disease, viz. that of vine (*Plasmopara viticola*), has been indicated by REICHERT (10).

Observations carried out by the staff of the Division of Plant Pathology in recent years have shown that distribution of downy mildew of cucumbers in Palestine during the summer months is limited chiefly to the coastal plain where dew is copious, while the disease is absent from the dry inland valleys (Jordan Valley, Beisan Valley, Eastern Valley of Esdraelon). The results of these observations appeared to favour the assumption that the presence

Under the auspices of the Meteorological Research Council, Jerusalem.

of dew is of decisive importance for the development of this downy mildew in Palestine. The studies described in this paper were made to test the foundations of this assumption.

In the experiments described in the following, use was made of the methods evolved by DUVDEVANI (5) in his studies on the effect of dew on the growth of crop plants. The climate of Palestine which, as mentioned above, entirely lacks summer rains, is particularly suitable for the determination of the effects of dew.

The cucumber crop in Palestine is irrigated either by furrows or through overhead pipe systems. In view of the fact that these two modes of irrigation might have different effects on the development of cucumber mildews on plots exposed to or protected from dew formation, it was clearly desirable to extend our studies to cover plots under either type of irrigation.

The experiments were carried out at Pardess Hanna, in the northern part of the coastal plain of Palestine.

The authors are indebted to Mrs. E. Gelman-Marcus for her devoted assistance in the estimation of the incidence of diseases on the experimental plots. Acknowledgement is further due to the Board of the Agricultural Secondary School, Pardess Hanna, for facilities to execute these studies.

II. METHODS

Meteorological Records

DEW. The essential features of the optical method of dew observation invented by DUVDEVANI (4) are as follows:

A dew gauge with a standard surface is exposed to dew formation from sunset until sunrise. The intensity of dew apparent on the standard surface is defined by comparison with a series of photographs representing various degrees of dew formation the equivalents of which in millimetres of dew has also been determined.

Fig. 1 illustrates the optic method of dew observation by reproducing 2 of the 11 degrees distinguished in the routine observations of dew in Palestine.

The advantages of this method of dew recording may briefly be summarized as follows:

(1) The equipment is extremely simple, and readings can be taken by anybody; simultaneous dew observations in numerous localities are thus possible.

(2) Evaporation does not materially affect optic dew estimation even if it continues for several hours of the night and dries part of the dew deposit.

(3) There is no danger of mistaking dew precipitation for that of rain, even where the latter is very slight (drops).

(4) The dew layer on the standard surface is readily comparable with that formed on most plants.

(5) If necessary, the dew deposit obtained on the standard surface for the whole or for part of the night may be weighed.

At the Dew Research Station attached to the Agricultural Secondary School of Pardess Hanna, where the present studies were made, dew was recorded every night under standard conditions of exposition at soil level and at heights of 5, 15, 50 and 100 cm above soil level, but on the sabbath nights (from Friday to Saturday) only readings at 100 cm height were taken. Although the height of the unstaked cucumber crop in our experiment did not exceed 30-40 cm, the data for the 100 cm level are also presented here because this is the standard level at which dew observations are being made throughout Palestine.

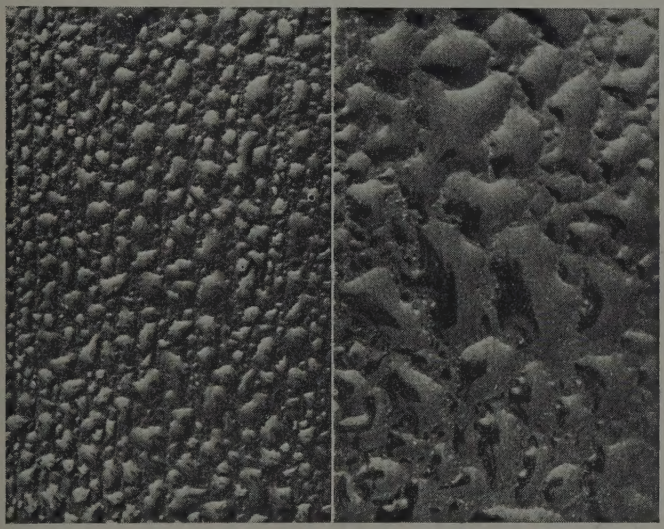


Fig. 1. Two of the 11 degrees of dew distinguished in dew observations by the optic method. The dew deposit on the left corresponds to a level of 2/3, that on the right to 4/5, of the Duvdevani dew scale.

Temperature. The temperature records kept included (a) Standard readings in the meteorological screen at 8 p.m. and at sunrise, and records of nightly minima; (b) Simultaneous readings taken on Fuess minimum thermometers exposed in the open at all those levels at which dew was recorded.

Evaporation. Evaporation between 8 p.m. and sunrise was measured by means of a Piche evaporimeter; readings were taken both in the meteorological screen and in the open at a height of 170 cm above soil level.

Humidity. Relative atmospheric humidity was measured in the open, in the shade of the meteorological screen, by means of an aspirated psychrometer, readings being taken at 8 p.m., at sunrise, and at 8 a.m. and 2 p.m. Palestine Standard Time.

Cultural details.

The soil of the experimental plots was light. The cucumbers of the local "Beit Alfa" selection were sown on 20th May, 1942 in rows 2.5 metres apart, with 40 cms distance between the hills in the rows. Germination was complete by the end of May, when all hills were thinned to 2 plants.

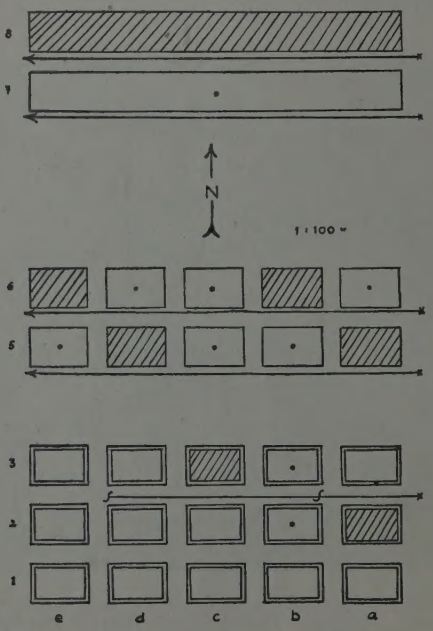


Diagram no. 1. Lay-out of the experiment.

The figures 1—8 indicate the numbers of the rows, the letters a-e the sequence of plots in the rows. Dew formation was prevented on the plots marked by oblique lines. Of the plots open to dew formation, those on which disease development was estimated have been marked by a black dot.

Rows nos. 1-3 were irrigated by sprinklers the position of which is marked by "S". Rows nos. 5-8 were irrigated by furrows, the water flowing in the direction indicated by arrows. Row no. 4, which received irrigation partly by overhead application and partly by furrows, was excluded from the experiment and has been omitted in the diagram.

Most of the plots were irrigated by furrows, but some plots received overhead irrigation from rotating sprinklers working at low pressure. Each experimental plot consisted of one row of 1.5 m. length. In addition to these small plots the experiment included 2 continuous furrow-irrigated rows of 19 metres' length in which the effect of dew on the development of cucumber mildews was observed under conditions comparable to those obtaining in actual practice. Diagram No. 1 indicates the lay-out of the experiment.

The plots were irrigated at intervals of 3-5 days, applications being always made near mid-day. Overhead irrigation was applied on each occasion for about one hour.

The principal experiment terminated on 4th September 1942 and only a few additional observations were made after that date.

When the plots were early in July attacked by larvae of Epilachna chrysomelina, these were hand-picked daily and little damage resulted. White flies (Trialeurodes vaporariorum) appeared in mid-July but caused no appreciable damage.

Prevention of Dew.

The plots serving as controls received no special treatment and were thus freely exposed to dew formation. On other plots formation of dew was prevented by a covering method used and tested previously in several years' experiments on the effect of dew on crop plants (5). This method essentially consists in covering the plants at night, from sunset to shortly before sunrise, with a canopy of cloth. In our experiments this canopy was 1 metre wide and fixed at a height of 70 cm. above soil level. The canopy was applied nightly from the 17th June to 4th September, 1942.

Estimation of Mildew.

The incidence of downy and powdery mildew was estimated on all the leaves of each of the plants selected for examination. On the small plots 4 such plants were selected at random from the total of 10 plants per plot. In the continuous rows (nos. 7 7and 8) groups of 4 plants were selected at random near the eastern and western ends and at the centre. In view of the fact that some dead leaves are always present at the bases of fully grown cucumber vines, irrespective of the presence of diseases, such leaves could not be taken into consideration in our estimations.

The incidence of DOWNY MILDEW was estimated by a method taking into account the proportion of leaf area affected as well as the stage of disease development, as apparent by the colour of most of the lesions. For this purpose the leaf was considered to consist of 6 equal portions, and 4 categories of infected area were distinguished:

(*a*) traces, or up to 1/6 of leaf area affected = 1 mark
(*b*) up to 2/6 leaf area affected = 2 marks
(*c*) up to 4/6 leaf area affected = 4 marks
(*d*) more than 4/6 leaf area affected = 6 marks

The stages of disease development in these estimations were

(i) the lesions are greenish-yellow = coefficient 1
(ii) the lesions are yellow = coefficient 2
(iii) the lesions turn brown and dry = coefficient 3

In the evaluation of results the number of marks assigned to each leaf in respect of leaf area affected was multiplied by the coefficient denoting the stage of disease development, and a single expression (degree of infection) was thus obtained.

This method of estimation and the disease ratings arrived at by its use are perhaps best summarised as follows:

Categories of infected leaf area	Marks for affected leaf area	Coefficient for stages of disease development		
		1	2	3
		Resulting ratings for degree of infection		
(a)	1	1	2	3
(b)	2	2	4	6
(c)	4	4	8	12
(d)	6	-*)	12	18

The total of these figures obtained on one plot was divided (1) by the total number of leaves found affected, to determine the average degree of infection *of diseased leaves;* (2) by the total number of leaves examined (diseased+healthy), to arrive at a figure expressing the mean degree of infection of the *entire plot.*

The incidence of POWDERY MILDEW was estimated by a more detailed assessing of the area affected, while the distinction between various stages of infection was not necessary at the time of estimation. Either leaf surface was divided into 3 equal portions, so that each leaf consisted of 6 portions. Estimation of powdery mildew consisted in assessing the proportion of area affected (1-6 marks). In addition, a distinction was made between area affected by separate small spots and area covered by a continuous growth of powdery mildew. Leaf portions affected with the former were given half the number of marks assigned to the latter. The results of this estimation were evaluated in the same way as the downy mildew estimations.

*) Where the amount of infected leaf area conforms to category (d), the coefficient for disease development always exceeds 1.

III. METEOROLOGICAL DATA AND THEIR VALIDITY IN THE FIELD

Table no.1 presents a summary of the meteorological conditions as recorded during the experimental period at Pardess Hanna in the meteorological screen and at various levels in the open. The records were made in the immediate vicinity of the experimental plots.

TABLE No. 1

Monthly meteorological data for June—September 1942.

Position and height (in cm. above soil level) of instrument	Month	Dew: Number of dew nights	Dew: Number of dew-less nights	Dew: Total amount of dew in mm.	Dew: Mean amount of dew per night of observation*) in mm.	Evaporation: Mean evaporation 8 p.m. — sunrise in mm. (Piche)	% relative humidity: whole day mean**)	% relative humidity: nightly mean***)	Mean temperature: 8 p. m.	Mean temperature: nightly minimum	Mean temperature: at sunrise	Mean temperature: nightly means=)
In the open, 5 cm					0.096				22.9	17.2	19.4	
„ „ „ , 15 cm					0.116				22.9	17.2	19.8	
„ „ „ , 50 cm	June	24	6		0.131				22.7	17.5	19.8	
„ „ „ , 100 cm				3.9	0.132				22.6	17.6	19.9	
Screen, 180 cm						0.63	59	73	24.7	19.3	20.7	22.0
In the open, 170 cm						0 63						
In the open, 5 cm					0.079				23.5	18.1	19.7	
„ „ „ , 15 cm					0.104				23.4	18.0	19.5	
„ „ „ , 50 cm	July	25	6		0.113				23.0	18.1	19.6	
„ „ „ , 100 cm				3.5	0.115				23.0	18.4	19.7	
Screen, 180 cm						0.45	66	78	24.9	19.7	21.0	22.3
In the open, 170 cm						0 45						
In the open, 5 cm					0.064				24.1	19.1	20.1	
„ „ „ , 15 cm					0.084				24.1	19.2	20.1	
„ „ „ , 50 cm	August	25	6		0.095				23.8	19.3	20.2	
„ „ „ , 100 cm				3.0	0.100				23.7	19.9	20.3	
Screen, 180 cm						0.45	65	82	25.1	20.8	21.4	23.0
In the open, 170 cm						0.45						
In the open, 5 cm					0.068				21.8	17.8	18.6	
„ „ „ , 15 cm					0.092				21.6	17.4	18.5	
„ „ „ , 50 cm	Sept-	27	3		0.098				21.4	17.3	18.3	
„ „ „ , 100 cm	ember			3.4	0.098				21.4	17.2	18.3	
Screen, 180 cm						0.53	64	80	23.1	19.3	20.2	21.2
In the open, 170 cm						0.62						

*) Nights in which readings were taken at all levels (cf. p. 129).
**) Mean records at 8 a. m., 2 p. m. and 8 p. m. divided by 3.
***) Mean records at 8 p. m. and sunrise divided by 2.
=) Mean = record at 8 p. m. and minimum temperature divided by 2.

Temperature. The data presented in the table show that the temperatures recorded in the open at 5—100 cm above soil level did not differ appreciably, the differences usually not exceeding 0.5°C. But well-marked differences are apparent between the readings taken in the screen at 180 cm height and those taken in the open at the above heights. This difference was frequently of the order of 2.0°C; it is due to a considerable extent to the cooling of open air thermometres by radiation and evaporation which likewise affects the surface temperature of plants.

Dew. The number of dew nights was 24-25 in June, July and August, and rose to 27 in September, so that there remained only 3 dewless nights during the latter month. The monthly total of dew decreased at all the levels recorded from 3.9 mm in June to 3.0 mm in August. The amount of dew per night similarly decreased during that period.

As regards the amounts of dew at various levels, those recorded at 50 cm and 100 cm above soil level were almost identical and always definitely above those at 15 cm, and even more above those at 5 cm or at soil level. This, of course, applies only to standard conditions of exposure, i.e. on non-irrigated soil. We note that the dew recorded at the 5 cm level amounted to 64-70% of that at the 100 cm level.

According to Duvdevani's (5) findings, the dew deposit of cucumber leaves exposed to heavy dew formation is generally to be denoted as 2 degrees (of the optical dew scale) below that simultaneously formed on the standard surface of the dew recording instrument at the 100 cm level. The weight of the dew formed per unit surface of an exposed cucumber leaf amounts on average to 6/10 of the comparable figure on the instrument.

Evaporation. The amount of evaporation decreased from June to July-August. There was no difference in the mean evaporation (8 p.m.—sunrise) recorded in the open and in the screen in July—August, but some difference was apparent in September. Such differences might be explained by the higher rate of open air drying on windy or khamsin (dry) nights.

Relative humidity. The mean relative humidity rose in July to about 65 percent. for the 24-hour period, and to about 80 percent. for the hours of the night, and remained near these figures in August and September.

IV. EFFECT OF DEW ON DEVELOPMENT OF DOWNY AND POWDERY MILDEW OF CUCUMBERS

The first symptoms of powdery mildew were recorded on 16th June, those of downy mildew on 12th July 1942. An estimation of the development of powdery mildew on plots exposed to or protected from dew formation was carried out on 3rd-13th July, while the corresponding estimation of downy mildew development took place on 23rd—31st July 1942.

A. *Powdery mildew.*

Table No. 2 presents the results of the estimation of powdery mildew development on the experimental plots.

TABLE No. 2

The effect of dew on the development of powdery mildew of cucumbers on plants irrigated by furrows or by overhead irrigation (3rd—13th July, 1942).

Treatment	Mode of irrigation	Symbol of plots	Number of plants \| leaves examined on each row*)		% of infected leaves		Average disease rating of infected leaves		Average disease rating of all leaves	
					per row	mean	per row	mean	per row	mean
Dew	furrows	7	30	733	59		1.6		0.9	
		6a, c, d	30	716	66	66	1.8	1.9	1.1	1.2
		5b, c, e	30	949	73		2.3		1.7	
Dew excluded	furrows	8	30	671	62		1.4		0.8	
		6b, c	20	599	71	70	2.1	2.1	1.4	1.4
		5a, d	20	722	76		2.8		2.1	
Dew	overhead	3b	4	207	73	76	2.7	3.1	2.0	2.4
		2b	4	192	78		3.5		2.7	
Dew excluded	overhead	3c	4	119	76	77	3.0	3.1	2.3	2.4
		2a	4	119	78		3.2		2.4	

*) Desiccated leaves at the bottom of vines were not examined.

The above figures permit the following conclusions: On furrow irrigated plots the presence or absence of dew did not affect the development of powdery mildew, and neither the percentage of affected leaves nor the degree of infection differed appreciably on leaves exposed to or protected from dew.

As regards overhead irrigation, the small number of plants under such irrigation which was examined by us does not suffice for general conclusions concerning powdery mildew development. However, we may tentatively conclude that under this form of irrigation, as under furrow irrigation, the presence or absence of dew does not affect powdery mildew development.

Both on the dewless plots and on those exposed to dew formation the incidence of powdery mildew rose gradually from the lowest values in rows 7 and 8 to the highest values in row 2 (cf. diagram 1). We suspect that some cultural factor may be at least partially responsible for this phenomenon and prefer, therefore, to refrain from a comparison of the respective effects of overhead and furrow irrigation on powdery mildew development.

B. Downy Mildew.

Table No. 3 summarizes the results of our estimation of the effect of dew on the development of downy mildew of cucumbers.

TABLE No. 3

The effect of dew on the development of downy mildew of cucumbers on plants irrigated by furrows or by overhead irrigation. (examined on 23rd to 31st July 1942, approximately two weeks after the first record of downy mildew).

Treatment	Mode of irrigation	Symbol of plots	Number of plants / leaves examined on each replicate plot		% of infected leaves		Average disease rating of infected leaves		Average disease rating of all leaves	
					per replicate	mean	per replicate	mean	per replicate	mean
Dew	furrows	7*)	12	339	43		5.0		2.1	
		6d	4	96	63		4.7		3.0	
		6c	4	81	53		7.0		3.5	
		6a	4	143	59	62	8.0	6.8	4.6	4.1
		5e	4	143	66		6.0		3.8	
		5c	4	149	66		8.0		5.0	
		5b	4	116	66		7.1		4.4	
Dew excluded	furrows	8*)	12	204	6		2.7		0.1	
		6e	4	97	3		1.3		0.04	
		6b	4	139	36	31	3.2	2.7	1.2	1.0
		5d	4	160	33		3.0		1.0	
		5a	4	119	53		3.3		1.8	
Dew	overhead	3b	4	172	67		7.1		4.8	
		2b	4	93	59	63	6.3	6.7	3.6	4.2
Dew excluded	overhead	3c	4	163	55		3.5		2.0	
		2a	4	125	53	54	3.0	3.3	1.6	1.8

*) In view of the fact that plots nos. 7 and 8 consisted of long continuous rows, where microclimatic conditions may have differed somewhat from those obtaining on the small plots under the same treatment, the estimated incidence of downy mildew on these 2 plots was not taken into account in calculating mean values per treatment. These means are thus based on the estimates of disease incidence on the small plots only.

The figures presented in table No. 3 may be interpreted as follows:

Furrow-irrigated plots.

On furrow irrigated plots prevention of thefo rmation of dew on the leaves very markedly checked the development of downy mildew. In the first place the percentage of infected leaves decreased sharply, from 62 percent. on dew plots to 31 percent. on dewless plots. Secondly the degree of infection of each affected leaf was reduced from 6.8 marks on the former to 2.7 marks on the latter plots. These two effects of the exclusion of dew found their expression in a reduction of the average disease rating for all leaves to only one quarter of that obtained on dew plots (1.0 as compared with 4.1 marks).

The values determined on the various plots from which dew was excluded fluctuate considerably, while these values were fairly uniform on the plots exposed to dew. This would appear to be due to the well-known phenomenon of fluctuations increasing where one of the decisive factors (in this case the presence of free water on the leaf) approaches its minimum level. Under these conditions undue prominence may well be given in the results of our estimations to the effects of factors irrelevant to the main issue, such as accidental differences in the rate at which water may have been supplied to the plots, or differences in the number of leaves that may at one time or another have projected beyond the dew canopy.

The difference in downy mildew development on plots exposed to and protected from dew was apparent at a glance, as will be seen from fig. 2.



Fig. 2

Front: A cucumber plot on which dew formation has been prevented: The plants are well developed; no symptoms of downy mildew are apparent, but in their absence powdery mildew is much in evidence.

Back: A cucumber plot exposed to normal dew formation. The leaves have largely dried up owing to downy mildew attack and only the bare stalks still persist.

Another observation made on the plots protected from dew likewise illustrates the importance of the latter for downy mildew development: On cucumber vines the top part of which projected beyond the canopy, the fully developed leaves near the top were often infected, while the older leaves that had been under the canopy were free from disease. There were even cases where a single leaf was infected on that part of its blade that had been exposed to dew while downy mildew failed to develop on the part protected from dew.

Plots under overhead irrigation.

As mentioned previously, the number of test plots under overhead irrigation was limited. Though not sufficient to permit final conclusions, these plots served for some interesting observatoins. The percentage of leaves affected by downy mildew was here not much higher in the presence than in the absence of dew. On the other hand, the degree of infection of each infected leaf was only half as much on the plots protected from dew as on those exposed to dew formation. As a result, the average disease rating for all leaves amounted to 1.8 marks on the former as compared with 4.2 marks on the latter. The high percentage but low degree of infection on the plots from which dew was excluded may perhaps be taken to indicate that the conditions created by overhead irrigation favoured initial infection, while the absence of dew prevented subsequent development of the disease.

Downy mildew development as affected by mode of irrigation.

Comparing the results obtained on plots under furrow and overhead irrigation, in the presence or absence of dew, we have to bear in mind that each application of overhead irrigation in this trial lasted for about 90 minutes only and was made about mid-day.

In the presence of dew, the latter constitutes the decisive factor overriding any possible differential effect of the two modes of irrigation. This is clearly brought out by the fact that the figures for percentage of infected leaves, degree of infection, and average disease rating were practically identical on those plots under furrow or overhead irrigation that were exposed to dew. However, in the absence of this overriding factor, considerable differences in downy mildew infection became apparent on dewless plots irrigated in either of the above ways. Overhead irrigation was seen to favour disease development more than furrow irrigation, with the percentage of infected leaves being 54 for the former as against 31 for the latter, and the corresponding figures for degree of infection being 3.3 as against 2.7 marks, and for the average disease rating 1.8 as against 1.0 marks.

It does not appear likely that increased downy mildew development on the plots under overhead irrigation was due to any *direct*

effect of this mode of irrigation. In the first place, according to results reported from abroad (12), the water splash should have reduced rather than favoured sporulation. Secondly, water is applied by overhead irrigation to the upper leaf surface only, while downy mildew chiefly attacks cucumber leaves from their undersides. Thirdly, water applied to the leaves for a limited period in the middle of the day may be assumed to have dried rapidly after the irrigation was terminated. We are therefore inclined to think that overhead irrigation could have directly assisted downy mildew development only in one respect, viz. by moistening those innermost leaves that are normally protected from dew by the younger leaves developing above them. These inner leaves are reached by overhead irrigation and, once moistened, are slower to dry than the upper leaves. However, this effect can hardly have been of decisive importance and clearly does not suffice to explain the stimulation of downy mildew development by overhead irrigation.

The *indirect* effect of overhead irrigation, however, would appear to be much more significant. On plots irrigated by overhead application the entire soil and upper leaf surface is moistened, and atmospheric moisture in the vicinity of the plants is thus increased. But on furrow irrigated plots only the narrow belt of the furrow and the soil immediately adjacent to it, to a total width of about 40 cm., is moistened in the course of irrigation. It follows that the amount of dew liable to form on plots under overhead irrigation will exceed that on furrow irrigated plots where only the leaves next to the furrow will enjoy a copious layer of dew. This explains the observation frequently made by growers, that downy mildew is most severe near the irrigation furrows. Moreover, as will be shown below, the moisture conditions created by overhead irrigation increase the rate of guttation, and this in turn may favour downy mildew development in excess of that experienced on furrow irrigated plots.

Downy mildew development in the absence of dew.

The fact that on plants protected from dew formation development of downy mildew still reached between one third and one quarter of the infection on plants exposed to dew, requires some explanation. On first thought, it may appear puzzling how — in a climate devoid of summer rains — downy mildew could possibly have succeeded in developing at all in the absence of dew. Some of the outer leaves on the plots shielded from dew may of course occasionally have protruded from their canopy and may then have been exposed to dew and downy mildew. But this will not explain development of the mildew on some of the inner leaves, as witnessed on several of the plots. These infections appear to us to have been possible chiefly owing to the presence of guttation moisture on the leaves.

DUVDEVANI (5), in his studies of the effect of dew on cucumbers, found guttation of the leaves of this crop to be strong. Table No. 4 presents some of the guttation values recorded, and shows that guttation was fairly strong even on plots protected from dew. The table also indicates that the rate of guttation depends to some extent on the mode of irrigation. As mentioned above, guttation was always heavier on plots under overhead irrigation than on furrow irrigated plots and this may at least partly account for heavier downy mildew infection on dewless plots under the former as compared with those under the latter mode of irrigation.

TABLE No. 4

The effect of dew and irrigation on the rate of guttation of cucumber leaves.

	Mean guttation values (0 = no guttation 4 = maximum guttation)			
	June 19-30.6.42	July 1942	August 1942	Mean June-August
Exposed to dew, furrows	3.1	2.4	1.7	2.4
Protected from dew, furrows	1.8	1.2	0.5	1.2
Exposed to dew, overhead	3.4	2.9	2.3	2.9
Protected from dew, overhead	2.4	1.6	1.0	1.7

In addition, we have to bear in mind what has first been pointed out by YARWOOD (13), that the sporangia of *Pseudoperonospora cubensis* may germinate not only by the liberation of zoospores dependant on the presence of free water, but also sometimes by the production of germ tubes. In the latter event, the presence of free water is not essential, and infection may evidently ensue even in the absence of dew.

V. ENVIRONMENTAL CONDITIONS CONDUCIVE TO THE OUTBREAK OF DOWNY MILDEW OF CUCUMBERS IN PALESTINE

The results of our experiments have shown that the presence of dew is essential for epidemic development of downy mildew of cucumbers under the conditions obtaining in summer at Pardess Hanna, and these conditions may be considered typical of the northern part of the coastal plain of Palestine. But our observations further showed that even where dew conditions were favourable, the disease did not always appear. We therefore analysed the meteorological data recorded for the experimental period and attempted to bring them into relation with our observations on disease development. For this purpose use was also made of observations carried out on the experimental plots after termination of the experiment proper. As stated above, protection of the dewless plots by nightly application of canopies was discontinued on 4th September 1942. These plots were therefore exposed to dew and downy mildew infection, the progress

of which was observed. In addition, observations were made on another plot of cucumbers that germinated on 27th July and was soon destroyed by downy mildew.

The meteorological data appropriate to the above periods of observation are presented in table No. 5, together with notes on downy mildew development. In discussing these data and their relation to disease development there is one important point to be constantly borne in mind. As shown above, strong development of downy mildew in this country depends on the presence of dew, and thus most probably also on the length of the night during which dew is present. In Palestine the length of the night in June is 10 hours, extending to 12 hours in September. It follows that no single set of meteorological data is likely to cover the conditions conducive to disease development at all seasons, and seasonal changes in the length of night must be duly considered.

A. September 1942. As the first step, we shall examine the progress made by the downy mildew on the plots previously protected from dew formation after nightly application of the canopies was discontinued, on 4th September. Those plots were first inspected on 10th September, when a total of about 30 lesions was found on leaves hitherto free from disease. We may assume with certainty that a few of these lesions were already present the previous day. During the nights of the 5th and 6th September, dew was present on the leaves in considerable amounts, while during the nights of the 7th and 8th September there was little dew which dried up rapidly. It may thus be concluded that the favourable conditions prevailing during the first two nights in which these plots were exposed to dew enabled the downy mildew to infect cucumber leaves. This is equivalent to stating that in early September downy mildew may establish infections in the course of two nights with dew on the dew gauge at the 100 cm. level, of an intensity conforming to the 2/3 or 3 level of the dew scale, with a minimum temperature of 18.1 -19.1°C at 15 cm above soil level in the open or of 20.2-20.8°C in the standard screen, and with a nightly mean of 22.6-23.1°C as recorded in the screen. Similar temperature conditions also prevailed during the nights of the 7th and 8th September, when only the humidity level was lower. Under these conditions the incubation period of the downy mildew did not exceed 3-5 days, and it could readily be seen to sporulate after this period.

The same plots were again examined on 14th September, when no development of downy mildew additional to that seen on the 10th of the month could be detected. This observation confirms that small amounts of dew do not suffice to induce infection, the intensity of dew between the 7th and 13th of September being always at or below that denoted by 1 in the dew scale. As pointed out on p. 134, so low a dew deposit on the dew gauge would correspond to a negligible amount of dew formed on cucumber leaves.

TABLE No. 5

Daily meteorological records for the observation periods.

Date	Dew Intensity=)	Relative Humidity*)	Temperature nightly minimum at 15 cm. height, in the open	Temperature nightly minimum in the screen	Temperature nightly mean**)	
June 1942						germination 23rd May
1	0	85	15.2	17.8	20.0	
2	0/1	83	15.6	17.9	19.5	
3	+4	90	16.0	17.7	19.8	
4	0	51	15.7	19.3	21.7	
5	0	35	17.4	23.1	24.1	
6	0	—	—	20.1	24.9	
7	0/1	80	16.1	17.3	19.3	
8	1/2	82	15.3	17.1	19.2	
9	3/4	85	14.3	16.8	19.2	
10	2/3	74	14.0	17.1	19.8	
11	+2	58	17.3	19.2	23.4	
12	1/2	73	17.2	18.9	21.7	
13	4/5	—	—	18.8	21.1	
14	0	61	13.3	15.8	18.7	
15	3/4	89	18.6	19.7	21.3	
16	(2/3)	88	19.8	20.8	22.1	
17	4/5	—	16.4	18.3	20.7	
18	2/3	83	16.2	18.6	20.9	
19	4/5	91	16.4	18.7	20.6	
20	5	—	—	19.3	24.0	***)
21	3/4	52	18.6	22.3	27.5	
22	(1)	50	21.8	23.6	30.0	
23	0	64	23.1	23.8	27.2	
24	3	84	18.7	20.4	23.0	
25	(+1)	79	17.8	20.0	21.8	
26	0	76	17.2	18.9	21.6	
27	1/2	—	—	18.9	21.3	
28	2/3	85	17.8	19.1	21.4	
29	2/3	85	18.8	19.7	21.9	
30	3/4	87	19.2	20.2	21.6	
July 1	2/3	78	17.6	18.9	21.7	
2	0	75	17.1	18.6	21.4	
3	0	78	18.2	19.4	21.8	
4	1	—	—	19.9	22.0	

*) mean nightly relative humidity = sum of records at 8 p. m. and at sunrise, divided by 2.

**) mean nightly temperature = sum of record at 8 p. m. plus nightly minimum, divided by 2.

***) khamsin (dry wind) during part of the night; dew as a result of mist.

=) Brackets in this column indicate that the dew deposit had largely dried off.

TABLE No. 5 (continued)

Date	Dew (Intensity=)	Relative Humidity*)	Temperature nightly minimum at 15 cm. height, in the open	Temperature nightly minimum in the screen	Temperature nightly mean**)	
July						
5	2	85	17.2	19.3	21.7	
6	2/3	77	17.4	20.0	21.9	
7	2/3	86	17.1	19.8	22.2	
8	2/3	83	16.9	19.3	22.3	? first symptoms
9	(2)	84	19.2	20.5	22.7	of downy mildew
10	2/3	83	18.9	19.9	22.1	
11	2/3	—	—	20.3	22.7	
12	0	76	19.9	20.3	22.6	first record of sporulating downy mildew
July 1942						
27	3	85	18.1	20.5	22.6	germination of 2nd exp. plot
28	2/3	83	19.0	20.8	23.1	
29	3	83	19.1	20.2	22.7	
30	(+2)	68	17.1	19.3	22.7	
31	+1	81	19.3	21.3	23.7	no symptoms of downy mildew
August						
1	2	—	—	21.0	22.9	
2	2	86	21.5	22.2	24.2	
3	3/4	87	21.0	21.9	24.4	
4	4	87	19.2	21.2	23.4	
5	+1	81	19.0	20.3	22.7	
6	+4	90	17.6	20.0	22.6	several days old lesions on cotyledons
7	+2	95	18.9	20.3	22.9	first downy mildew record on leaves
September						
4	2/3	87	19.0	20.8	22.9	application of dew canopies discontinued
5	3	—	(19.1)	21.1	23.1	
6	2/3	89	18.5	20.3	22.4	
7	+1	74	18.4	19.9	21.8	
8	1	81	18.1	19.9	22.1	
9	0/1	71	17.0	19.5	21.6	
10	0	68	17.5	19.6	21.4	30 leaves newly infected with downy mildew
11	0/1	80	18.9	20.2	21.7	
12	1	—	—	17.8	20.3	
13	1	—	—	17.8	20.0	
14	2	77	15.5	18.2	20.2	no additional infection
15	1/2	78	15.6	18.0	20.4	
16	0/1	73	16.4	18.4	20.8	
17	1/2	78	17.9	20.0	22.0	
18	2	80	16.2	19.0	21.6	
19	0	—	—	20.0	21.4	
20	1/2	—	—	19.4	21.3	
21	2/3	—	—	17.9	20.0	
22	3	—	—	19.0	21.2	
23	3	81	17.1	19.3	21.4	most leaves infected

The final observation on these plots was made on 23rd September, when most of the leaves were found affected with downy mildew. Infection may be assumed to have taken place between the 14th and 21st September. Of this period two nights were dewless (16th and 19th) and there remain three two-day periods in which infection was possible. In these nights the intensity of dew was moderate (1/2 to 2/3) and temperatures were lower than early in September: the nightly minimum was about 16°C (only once 17.9°C) when recorded at 15 cm above soil level in the open, and 18-19°C as recorded in the standard screen, and the nightly mean in the screen was 20.0-21.6°C (only once 22.0°). These observations lead us to conclude that during the second third of the month of September the above conditions enable downy mildew to infect cucumber leaves, and that such infection may be established after 2-3 consecutive nights of moderately heavy dew. No conclusions concerning the length of the incubation period under these conditions can be drawn from these observations.

B. July-August 1942. On the additional plots sown on 23rd July and germinating on 27th July 1942, the first symptoms of downy mildew appeared on the cotyledons after 31st July and before 6th August. We are inclined to assume that initial infection (inoculation) took place between the 27th and 29th July. During these 2-3 nights temperature and moisture conditions in all respects resembled those of the 5th and 6th September when infection has above been shown to have been effected on plots previously protected from dew. Under these conditions downy mildew appeared on the cotyledons of these young plants after 4-7 days of late July and early August.

On the true leaves of the cucumbers of this sowing the very first symptoms of downy mildew were noted on 7th August. After germination of these plants on 27th July, these leaves were first formed between the 30th July and 2nd August. Doran (2) has pointed out that the youngest leaves of cucumbers are not susceptible to infection by *Pseudoperonospora cubensis* because they are hairy and not easily wetted and their stomata are closed. But according to our observations the young leaves must have contracted the disease almost immediately after their opening as symptoms were observed only 5 days later. During four out of these five nights the intensity of dew was considerable, and the nightly minimum temperature at 15 cm above soil level in the open amounted to 18-21°C.

C. June-July 1942. On the main experimental plot, sown on 23rd May, the first symptoms of downy mildew were recorded as late as 12th July. The number and conditions of lesions then found leads us to assume that the very first symptoms of disease may have appeared between the 8th and 10th July. A period exceeding 6 weeks thus passed between sowing and disease appearance, and we shall in the following attempt to show how far the meteorological data recorded near the plot may explain this phenomenon.

As evident from table No. 5, the minimum temperature recorded at 15 cm height in the open failed to rise above 16.0°C during the first 8 days of June, with the exception of one khamsin night (dry wind). From the 8.h to the 10th of June, dew intensity reached that denoted by 1/2 to 3/4 in the dew scale, which apparently sufficed for downy mildew development in September, but minimum temperatures were low (14.0-15.3°C) and the disease failed to appear. On the 11th June atmospheric humidity was low and dew moderate. On the 12th June dew was also moderate, but on the 13th dew was copious, and temperatures in both nights were above the level at which infection took place in September. The following day was again a khamsin day. From the 15th to the 19th of June, for 5 nights, both dew and temperature conditions appeared to favour downy mildew, if compared with those prevailing in mid-September, but no infection ensued. This period was followed by four khamsin nights. On the 24th June there was a single night of fairly heavy dew and a rather high minimum temperature, but this was again followed by three more or less dry nights. This brings us to the 28th of June. Beginning on this date and extending to 1st July inclusive there was a continuous series of nights in which dew intensity conformed to the level expressed by 2/3 to 3/4, minimum temperatures amounted to 17.6-19.2°C at 15 cm height in the open and to 18.9-20.2°C in the standard screen, and mean temperatures in the screen were 21.4-21.9°C. It is during these four nights that most of the infection appears to have taken place which resulted in the appearance of readily visible symptoms between the 8th and 12th July. Infection could not be effected during the three following nights (2nd-4th July) because they lacked dew, and only the nights between the 5th and 8th of July could again favour establishment of the disease.

The above survey of downy mildew development in relation to meteorological conditions in June and early July appears to warrant the following conclusions: During these months even five consecutive nights with ample dew and high atmospheric humidity did not suffice for the infection of cucumber leaves by downy mildew if the nightly minimum temperature at 15 cm above soil level, in the open, amounted to 16.5-17.0°C or less. Infection took place, however, when the minimum temperature rose to 18.0°C. Under these conditions the incubation period appeared to have lasted for about 8-10 days.

We may add that failure of downy mildew to develop on cucumbers in June may have its causes not only in unsuitable meteorological conditions, but possibly also in the absence of sufficient inoculum during that month. The mode of overwintering of the disease in Palestine is as yet undetermined, but first signs of the disease are usually recorded in the coastal plain not before late June, and rarely in late May.

All the above observations concerning the effect of different meteorological conditions on downy mildew development at different seasons of the year may be summarized as follows:

The inoculation period. The period elapsing between germination of the spore and establishment of infection in a manner ensuring its further development in the leaf tissue even under less favourable conditions, which may be termed the inoculation period, lasts in June-July — under what seems to approach optimum temperature conditions with nightly minima at 15 cm height, in the open, of 18.0°C or above — for at least 3 nights; whether or not the length of the inoculation period in August and September could be shorter, was not determined, but 2-3 consecutive nights with favourable conditions sufficed in each of these months for infection to be established.

Temperature. At nightly minimum temperatures of 16.5-17.0°C (at 15 cm height, in the open) infection failed to take place in June even in 3 consecutive nights with ample dew. In this month and early July infection seemed to succeed only when the nightly minimum rose to 18.0°C or above. In mid-September, on the other hand, when the nights are longer, infection was established also during nights with minimum temperatures of about 16.0°C.

Incubation period. The period elapsing between penetration of the fungus into and appearance of readily visible downy mildew symptoms on cucumber leaves appeared to last in June-July for 8-10 days, but in early September for only 4-5 days.

VI. DISCUSSION

A. Downy mildew of cucumbers and the conditions of its development

1. Temperature during the inoculation period.

As pointed out above, downy mildew infection took place in September in nights with minimum temperatures of about 16.0°C, but in June-July only when this temperature rose to 18.0°C or above. A survey of temperature relationships of *Pseudoperonospora cubensis*, as determined in studies abroad, may help to explain this difference.

Most of the biological research on *P. cubensis* has been carried out in U.S.A. and Japan. Kurosawa (7) found the minimum, optimum, and maximum temperatures for zoospore germination to be 9, 20-22, and 30°C, respectively. Hiura (6) reported the corresponding figures for sporulation to be 10, 15-19, and 27°C, and for spore germination 4, 15-19, and 30-32°C, respectively. The same author concluded from field observations that the minimum level of temperature for primary infection is 10-15°C, and the optimum for disease development approximately 20°C. Doran (3) has shown that conidial germination takes place between 9 and 30°C, with an

optimum at 16-19°C. VAN HALTERN (11) has stated with regard to the downy mildew of cantaloupes, that conidia of the fungus germinate best at 19-21°C.

Our observations regarding the difference in the development of downy mildew on cucumbers in June-July and September, may be explained if the differences in the length of nights in summer and autumn are taken into account. In the 10-hour night of June, the fungus has to develop rapidly to reach that stage of inoculation in which the drought of the following day can no longer destroy it, and this evidently requires temperatures approaching the optimum. A nightly minimum (at 15 cm height, in the open) of 18-19°C, with a corresponding nightly mean of 20-22°C, appears to approximate this optimum level under field conditions in this country. These temperatures agree well with those defined by the above authors, and especially by KUROSAWA and VAN HALTERN, as optima for various phases in the development of *P. cubensis*. At lower temperatures the fungus fails to establish infection during the relatively short hours of dew of a June night. In the longer September nights, on the other hand, downy mildew manages to inoculate cucumber leaves even at temperatures of about 16°C. It appears, therefore, that temperatures somewhat below the optimum may render infection possible, if the fungus is given longer hours of dew to develop in. Our observations in early September further show that where combinations of optimal temperatures and long nights are encountered by *P. cubensis*, disease development is extremely rapid.

In addition to the greater length of September nights, the differences in downy mildew development in summer and autumn may in part also be explained on the basis of the following consideration: The temperature criterion chiefly used in the foregoing observations, the nightly minimum, has been chosen solely for reasons of convenience, as it represents the record most easily and reliably taken. But a more proper temperature criterion is represented by the nightly mean. Now there are several ways of calculating this mean, but the only really reliable way is that using hour by hour records from sunset until sunrise. We have reason to assume that nightly means of screen temperatures basing on such records would, in the month of September, yield a figure approximately 1°C above that of the mean calculated by adding the record at 8. p.m. to the minimum temperature and dividing the result by 2. We had to adopt the latter method because hour by hour records were not available, and our mean temperature figures for September are therefore rather too low. Conversely, in July nights we might expect the hour by hour mean to be about 1°C lower than that obtained by the use of our formula. Taking into account this consideration as well as the relative length of the night, we find that the temperature sum of the hours of the night differs markedly in the two months:

July:
nightly mean from actual records*) = 22.3°C
corrected nightly mean (22.3 minus 1°C) = 21.3°C
corrected temperature sum for 10-hour night thus amounts to 213

September:
nigthly mean from actual records = 21.2°C
corrected nightly mean (21.2 plus 1°C) = 22.2°C
corrected temperature sum for 12-hour night thus amounts to 266.4

i. e. the temperature sum (as calculated by degrees centigrade above 0°C) of September nights exceeds that of July nights by 25 percent. As it is this difference, rather than the mere difference in the level of nightly mean or minimum, which must be thought to affect mildew development, closer study of the correct method of calculating such temperature sums would be of interest.

2. Length of inoculation period.

According to Kurosawa (7) and Doran (3), 4-5 hours are required, at optimum temperatures and in the presence of free water, for the liberation and germination of zoospores and for the penetration of the germ tube of *P. cubensis* into the host leaf. It is relevant to recall here that the amount of dew formed on cucumber leaves is definitely less than that recorded on the standard dew gauge. It follows that even where ample dew eventually forms during the night, the earlier hours of that night may be devoid of dew sufficient for downy mildew development, and the number of hours in which free moisture is present in adequate amounts may not greatly exceed those required for infection at optimal temperatures.

Studies carried out in Massachusetts (9) have shown that spores of *P. cubensis* die as the free moisture on cucumber leaves dries up, and the spores are unable to survive a few hours of drought. We might therefore have assumed that, under the conditions obtaining on summer and autumn days in Palestine, when the leaves remain completely dry once the dew has evaporated, the fungus must penetrate into the leaf during the same night in which it liberates zoospores, and that the spores will die unless this is accomplished.

However, analysis of the meteorological data presented above has shown that downy mildew failed to appear in June although conditions were sometimes favourable during single nights of that month. This may be interpreted to indicate that in June successful inoculation to an extent ensuring further development of the fungus even during subsequent dry spells of weather, requires a number of consecutive favourable nights; as far as can be gathered from our observations 3-4 such nights are an essential prelude to the

*) 8 p.m. + minimum, divided by 2. Cf. table 1.

outbreak of cucumber downy mildew in mid-summer. This could be explained on the assumption that the phase of development reached by the fungus after the first and second favourable night will tolerate dry conditions for about 12 hours at a time, but that the fungus perishes when the drought period is extended considerably beyond this.

3. Length of incubation period.

Doran (3) has reported that 6 to 9 days elapse between penetration of *P. cubensis* into cucumber leaves and the formation of a new crop of spores. Van Haltern (11) found that the length of the incubation period on cantaloupe leaves extends from 4 to 13 days. Accurate determination of incubation periods in our experiments were hampered by the fact that observations could not be made every day. However, our records permit the conclusion that the length of incubation periods differed at various seasons. Only 4-5 days appeared to elapse between penetration of the leaves and appearance of downy mildew symptoms in early September, while 8-10 days were required in late June-early July.

B. Powdery mildew of cucumbers as affected by dew and overhead irrigation

The observations described above with regard to powdery mildew of cucumbers indicate that development of this disease is independent of the presence or absence of dew on the leaves. The high atmospheric humidity prevailing at night during the experimental period appeared to be adequate for powdery mildew development which required no free moisture on the leaves. This is in complete agreement with Brisley's (1) findings that the powdery mildew of cantaloupes develops in Arizona preferably under the conditions of high atmospheric humidity obtaining on cloudy or rainy days, while actual precipitation as rain or dew or the presence of free water did not appear necessary.

VII. SUMMARY

The effect of the presence or absence of dew on development of downy mildew of cucumbers (*Pseudoperonospora cubensis*) has been studied in the field on small plots on some of which dew formation was prevented by the nightly application, from sunset to sunrise, of canvas canopies. Most plots were irrigated by furrows, but some by overhead pipes. Some observations were also made concerning the development of powdery mildew of cucumbers (*Erysiphe cichoracearum*) on these plots.

The meteorological data recorded near the experimental plots included records of dew and temperature (in the open) at 5,15,50, and 100 cm above soil level, as well as standard records of temperature and humidity in the meteorological screen. In the light of

all these records the validity of readings taken in the screen for ecological definitions in the field has been examined; temperature readings in the screen were found to be constantly 1-2°C higher than those recorded in the open with which the surface temperatures of well exposed cucumber leaves may be expected to be in rough agreement. The amount of dew recorded on dew gauges at the height of the cucumber crop (15 cm) amounted to 65-70% of that apparent at the standard height of 100 cm. It is further pointed out that the amount of dew on cucumber leaves is smaller than that on standard surfaces used for dew recording.

Prevention of dew formation largely precluded downy mildew development, while the disease was severe on plots exposed to dew. This difference was most pronounced on plots irrigated by furrows, but was also well-marked on plots under overhead irrigation. The fact that downy mildew developed at all on plots protected from dew is probably to be ascribed to the presence of guttation moisture on these plots, and to the occurrence of direct germination of downy mildew spores to which the presence of free water is not essential.

Exclusion of dew failed to affect the development of powdery mildew of cucumbers.

Overhead irrigation somewhat increased downy mildew development. This was probably due not so much to its direct effect in moistening the leaves as to its indirect effect of increasing dew formation and guttation. Guttation records are presented in support of this view.

Analysis of daily meteorological records in relation to observations on the appearance and progress made by the downy mildew, has led to the following conclusions concerning the development of this disease in the coastal plain of Palestine:

(a) Cucumber leaves are liable to infection only when dew intensity conforms to the level denoted by 2 to 2/3 in the Duvdevani dew scale.

(b) The nightly minimum temperature required for downy mildew infection differs in June-July and September. In the 10-hour nights of mid-summer the disease will appear only when nightly minima reach 18°C or above (at 15 cm height, in the open). But in the 12-hour nights of September infection may also succeed in nights with a minimum of 16°C, and disease development is then very rapid if the minimum is as high as 18°C.

(c) The length of the inoculation period could be determined only in June-July, when 3-4 consecutive nights of favourable conditions were required for the purpose.

(d) As far as could be determined in these experiments, the incubation period of downy mildew on cucumbers lasted for 8-10 days in June-July, but only 4-5 days in September.

REFERENCES

1. Brisley, H. R. (1926). Recent information concerning powdery mildew in northern Arizona.
— U.S. Dept. Agr. Bull. Abstr. in Pl. Dis. Reptr. 10:104.

2. Doran, W. L. (1929) in Department of Botany, Biennial Report for the Fiscal Year Ending Nov. 30, 1927-28.
— Massachus. Agr. Exp. Sta. Bull. 247, pp. 306-313.

3. Doran, W. L. (1932). Downy mildew of cucumbers.
— Massachus. Agr. Exp. Sta. Bull. 283, 22 pp.

4. Duvdevani, S. An optical method of dew estimation. submitted to Royal Met. Soc., London, for publication.

5. Duvdevani, S. Dew in relation to plants. In preparation.

6. Hiura, M. (1929). Studies on some downy mildews of agricultural plants. II. Relation of meteorological conditions to the downy mildew of cucumbers.
— Res. Bull. 6, Gifu Imp. Coll. of Agric., 58 pp. (Japanese, English summary).

7. Kurosawa, E. 1927). Studies on Plasmopara cubensis.
— Journ. Nat. Hist. Soc. Formosa 17,18 pp. (Japanese).

8. Miller, P. A., & Barrett, J. T. (1931). Cantaloupe powdery mildew in the Imperial Valley.
— California Agr. Exp. Sta. Bull. 507, 36 pp.

9. Osmun, A. V. (1935). Department of Botany.
— Massach. Agric. Exp. Sta. Rept. 1934, pp. 23-4.

10. Reichert, I. (1927). Downy mildew (Plasmopara viticola) of the vine in Palestine.
— Yedeoth, nos. 7-8, 28 pp. (Hebrew with English summary).

11. Van Haltern, F. (1933). Spraying cantaloupes for the control of downy mildew.
— Georgia Exp. Sta. Bull. 175, 53 pp.

12. Yarwood, C. E. (193). The tolerance of Erysiphe polygoni and certain other powdery mildews to low humidity.
— Phytopath. 26 (9) : 845-859.

13. Yarwood, C. E. (1939). Relation of moisture to infection with some downy mildews and rusts.
— Phytopath. 29 (11) : 933-945.

DIPLODIA NATALENSIS, ITS OCCURENCE ON FLOWERS, BUTTON AND STEM-END OF SHAMOUTI ORANGE, AND ITS RELATION TO STEM-END ROT AND FRUIT DROP*)

By G. Minz

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

INTRODUCTION

Stem-end rot of Shamouti oranges, as indicated by its name, begins to develop at the stem-end of the fruit. *Diplodia* stem-end rot of Shamouti oranges occurs in nature at the beginning of the picking season and especially towards its end, as the temperatures prevailing at both these periods favour the development of the fungus. Fruits from old groves are generally more heavily affected than those from young groves (12). Storage experiments at temperatures of 18-20°C have shown that stem-end rot develops on stored fruit throughout the picking season (13,14,15). We may therefore assume that the fungus is probably present on or in the fruit during the whole season, but only produces rot when temperatures become favourable. Laboratory studies on the mode of infection have taught us that the causal agent of the rot can penetrate the various parts of the stem-end even if they are uninjured, whereas it cannot penetrate the uninjured peel of the fruit (16).

Earlier investigations by Fulton and Bowman (8) led to the conclusion that *Diplodia natalensis* P.E., the organism causing stem-end rot of citrus fruit, must already be present in some parts of the button before harvesting, and subsequently passes into the tissue of the fruit. Tisdale and West (21) isolated *Diplodia natalensis* P.E. from surface sterilized parts of buttons and stems of tree-ripe Valencia oranges and Silver Cluster grapefruit. Winston (22) regarded the organism as causing incipient infection of stem-ends, while the fruit is on the tree, the fungus being in or on the stem-end or parts of the stem at the time of harvest. Baker and Wardlaw (2) consider *Botryodiplodia theobromae* Pat. to be a wound parasite, which penetrates through the cut stem-end at the time of harvesting the fruit. The experiments of Winston, Fulton and Bowman (23) and of Reichert and Hellinger (18, 19) on the control of diplodia stem-end rot by debuttoning support the view that the fungus is present on the button.

*) Contribution from Citrus Wastage Investigations sponsored by the Department of Agriculture of the Palestine Government.

The above facts and observations led us to suggest that the entire stem-end (the button and the base of fruit) harbours the causal agent of diplodia stem-end rot. In the experiments reported here an attempt was made therefore, by means of cultures made from various parts of the stem-end throughout the season, to determine: (a) the presence of *Diplodia*, whether superficial or latent, on the stem-end of Shamouti orange fruits during all the stages of their development, from fruit set to maturity, and (b) which parts of the stem-end harbours the fungus.

For the sake of convenience we shall use the term "Total *Diplodia*" and "Latent *Diplodia*" in the following sense: total *Diplodia* will denote that the fungus was isolated from material without previous disinfection of the surface. It is therefore obvious that superficially lodged *Diplodia* will prevail here, while latent *Diplodia* may also develop. Latent *Diplodia*, on the other hand, will denote that the fungus was isolated from the tissue after surface disinfection. The latent *Diplodia* has to be distinguished from the term "latent infection" used in phytopathological terminology. Latent infection of fruits means that the fungus entering the tissue of the host is arrested in its mycelial development and remains dormant until definite conditions (ripening, harvesting, storage) favour its further development, eventually resulting in fruit rot. "Latent *Diplodia*" is used here to denote also the presence of spores imbedded in cavities of the stem-end, which the disinfectant can hardly reach and enter. Such proximity of spores may obviously be suspected to be the source of incipient infection by *Diplodia*.

SEASON 1938-39

Plan and methods

During the first year we selected two groves of which one was old and known to have a high natural incidence of diplodia stem-end rot, while the other was young, with a low natural incidence of *Diplodia*. Fruit with healthy buttons and fruits with buttons the sepals of which had wilted were taken from each of these groves. Cultures were made from the stem-end immediately after picking as well as three days later, in order to determine whether the fungus had meanwhile penetrated into the cut stem-end through the wound caused by picking. Part of the cultures was made without previous disinfection to study the part played by *Diplodia* in the flora of the stem-end, and the remainder was disinfected (3 seconds in alcohol 96%, followed by 60 seconds in corrosive sublimate 1:1000, and rinsed with sterile water) in order to establish the presence of the fungus within the tissue of the stem-end. The cultures were plated out with neutral 2% potato dextrose agar, and incubated at 25°C. The experiment was carried out in two replications in March 1939 when the fruit had reached full maturity. Each item of the first replication comprised 6, and of the second replication 5 fruits, the total number of fruit used in the experiment amounting to 176. The stem-end of

each fruit was cut lengthwise into halves of which one was used for culturing and the second for anatomical study (17). For the purpose of culturing the stem-end was divided into four parts: (1) cut stem-end, (2) receptacle, (3) base of fruit and (4) sepals (fig. 1).

Results

The presence of Diplodia on and in the stem-end

Both total and latent *Diplodia* were far more frequent on the stem-end of fruits picked from the old than in those from the young grove (table 1). This confirms previous findings (12).

The ratio of latent to total *Diplodia* was higher in the old grove (1:2) than in the young one (1:3.5) (table 1).

TABLE 1.

The incidence of latent and total Diplodia on the stem-end of Shamouti oranges from old and young groves (March 1939).

	Old grove								Young grove							
	Number of fruits								Number of fruits							
	examined	affected on				total	fruit affected %	L:T	examined	affected on				total	fruit affected %	L:T
		C	R	B	S					C	R	B	S			
Latent Diplodia	44	4	5	10	3	16	36.4	1:2	44	2	2	2	3	4	9.1	1:3.5
Total Diplodia	44	15	18	22	18	32	72.7		44	6	7	6	4	14	31.8	

C — cut stem-end, R — receptacle, B — base of fruit, S — sepals, L:T — ratio between latent and total Diplodia.

The incidence of total *Diplodia* on the stem-end was, in the fruit from both groves, higher when the sepals had wilted than when they remained green (table 2). As far as the sepals themselves are concerned, the incidence of total *Diplodia* was higher on wilted than on green sepals only in the case of fruit originating from the old grove; on the other hand, the state of sepals did not appear to affect the incidence of latent *Diplodia* on sepals or on the whole stem-end of fruit from either grove.

TABLE 2.

The incidence of latent and total Diplodia on sound and wilted sepals and on the whole stem-end of Shamouti oranges from old and young groves (March 1939).

Sepals		Old grove			Young grove		
		Number of fruits			Number of fruits		
		examined	affected		examined	affected	
			S	S.E		S	S.E
Sound	Latent Diplodia	22	2	6	22	2	1
	Total Diplodia	22	6	13	22	2	2
Wilted	Latent Diplodia	22	1	8	22	1	2
	Total Diplodia	22	12	18	22	2	10

S — sepals, S.E — stem-end as unit.

The incidence of *Diplodia* in cultures from disinfected buttons made after three days of storage did not differ from that in cultures made immediately after picking. Infection through cut stem-ends did not seem to occur during this period.

The distribution of Diplodia on the stem-end

In the young grove the distribution of *Diplodia* was more or less uniform over all parts of the stem-end. In the old grove *Diplodia* was of relatively more frequent occurrence on the base of the fruit than on other parts of the stem-end. This, as shown in table 1, is clearly significant in the case of the disinfected material (latent *Diplodia*).

The flora of the stem-end

The flora of the fungi found on the stem-end is presented in table 6. Besides *Diplodia* the following fungi causing stem-end rots of citrus fruits may deserve mention: *Phomopsis, Dothiorella, Colletotrichum* and *Alternaria.*

SEASON 1939-40

Plan and methods

In the second year the experiment was extended to determine the presence or absence of *Diplodia* on the fruits from fruit set until maturity. In addition, we investigated the effect of pruning affected branches in an old grove on the incidence of *Diplodia*, the presence of *Diplodia* on flowers, and the role played by *Diplodia* in the drying of sepals and fruit drop.

The experiment was carried out in an old grove on five unpruned and five pruned trees. Cultures were made as in the first year, viz. with and without previous disinfection of the material. Every experimental item consisted of ten fruits and a total of 640 fruits was used. The experiment lasted from May 1939 until April 1940; the total number of pickings, at intervals of three weeks, amounted to 16.

To determine whether or not *Diplodia* infects flowers, cultures were made with and without disinfection from all parts of the flower: the sepals, ovary, style and stigma, stamens, and petals. The cultures were made in the middle of April 1940, from 72 flowers collected before and immediately after fruit set from an old grove affected by *Diplodia.*

In the course of this season fruits with healthy buttons only were used in the experiment. The examination of affected sepals was carried out separately during those months when they were known to be abundant, i.e. February and March, in order to collect further evidence as to which fungi may infect and cause the drying up of the sepals. This investigation was made in an old and in a young grove. We distinguished in our study between sepals dried up entirely and sepals of which only the margins were affected. There were twenty buttons in each item, the total number being 160. Cultures were made after disinfection.

For the preliminary study of the role played by parasitic fungi in the occurrence of fruit drop, we examined 60 fruits which yellowed prematurely on the tree or had just dropped. The experiment covered the months of May to October 1939. The cultures from prematurely yellowed fruits were made from various parts of the button without any disinfection, while those from dropped fruits were made from the disinfected base of the fruit.

Results

In view of the fact that the incidence of *Diplodia* varied during the season as well as on the various parts of the stem-end, the results of our experiments may be considered under the following two headings, according to the development and maturity of fruit: I — from May to October (from the setting of fruit until it reaches full size); II — from November (incipient ripening) until April. In order to compare results with those of the first year, the period of March-April will also be treated separately.

Table 3 shows that during the later part of the season as well as in the aggregate of the data collected throughout the season, differences between pruned and unpruned trees were only small. In addition, these differences sometimes favour the pruned, and sometimes the unpruned trees. We therefore decided to regard the two groups of pruned and unpruned trees as replications, the results of which may be considered together.

TABLE 3.

The incidence of latent and total Diplodia on the various parts of the stem-end of Shamouti oranges from an old grove, from fruit set to maturity (1939-40).

Date	Pruned trees — Number of fruits affected by: Latent Diplodia					Pruned trees — Number of fruits affected by: Total Diplodia					Unpruned trees — Number of fruits affected by: Latent Diplodia					Unpruned trees — Number of fruits affected by: Total Diplodia				
	C	R	B	S	S.E	C	R	B	S	S.E	C	R	B	S	S.E	C	R	B	S	S.E
25. 5.39.						1				1						1		1	1	1
12. 6.39.						3	3	2	2	3	1	1	1	1	1					
3. 7.39.										no Diplodia										
26. 7.39.						2	2	2	2	3						1	1	2	1	3
16. 8.39.						1	1	1		2								1	1	1
11. 9.39.						1	1	1	1	2	1	1	1	1	1	1	1	3	2	3
2.10.39.						2	3	2	3	4		1	1	1	1	1	2	3	5	6
23.10.39.						2	3	3	3	7						3	5	5	4	7
13.11.39.	2	2	2	3	4	2	3	2	2	5							2	3	3	5
4.12.39.							2	2	2	5							1	1	4	6
25.12.39.	1	1			2	1	3	5	5	10						1	3	3	3	6
15. 1.40.		1			1	3		5	3	6	1	3	1		3		1	2	2	4
6. 2.40.		1			1	3	4	5	3	8		1			1		1		3	3
26.2.40.			1				3		3	5		1	1		1		2	2	2	4
17. 3.40.						2	3	2	4	7			1		1	1		1	3	3
8. 4.40.	1		1	1	2	1	2		3	4			2		2		1	1	1	1
Total	4	5	4	4	11	24	33	32	36	72	3	8	8	3	11	9	20	28	25	53

C — cut stem-end, R — receptacle, B — base of fruit, S — sepals, S.E — stem-end as unit.

The spread of total and latent Diplodia on and in the stem-end in the course of the season

Total Diplodia. Total *Diplodia* may be found to be present on the stem-end as early as May, i.e. on fruits which have only just set. The incidence of *Diplodia* gradually increases until December and decreases from January to April (table 3).

Latent Diplodia. Latent *Diplodia* begins to appear as early as June and continues to do so intermittently until November. Later in the season it is nearly always found much more frequently (table 2). Dividing the period of fruit formation and ripening into two seasons, viz. May-October and November-April, it will be seen that latent *Diplodia* is almost six times as frequent (11.9 as against 1.9 per cent) in the latter as in the former season (table 4). Total *Diplodia*, on the other hand, only doubled from the first to the second season. The ratio of latent to total *Diplodia* increased from the beginning to the end of the period of fruit formation and ripening, as follows: 1:14, 1:4, 1:3 (table 4). This table shows further that the increase of latent *Diplodia* took place in two of the stem-end parts, the receptacle and the base of fruit.

TABLE 4.

The incidence of latent and total Diplodia on various parts of the stem-end of Shamouti oranges from an old grove, from fruit set to maturity (1939-40).

Period		Number of fruits examined	affected on C	R	B	S	total	% fruit affected	L:T
May-Oct. 1939	Latent	160	2	3	3	3	3	1.9	1:14
	Total	160	19	22	26	25	43	26.9	
Nov. 1939— April 1940	Latent	160	5	10	9	4	19	11.9	1:4.3
	Total	160	14	31	34	46	82	51.2	
Mar.-April 1940	Latent	40	1	0	4	1	5	12.5	1:3
	Total	40	4	6	4	11	15	37.5	
May 1939— April 1940	Latent	320	7	13	12	7	22	6.9	1:5.7
	Total	320	33	53	60	71	125	39.1	

C — cut stem-end, R — receptacle, B — base of fruit, S — sepals. L:T — ratio between latent and total Diplodia.

The distribution of Diplodia on the various parts of the stem-end throughout the season

The differences in the distribution of *Diplodia* on the various parts of the stem-end throughout the period of fruit formation are set out in table 4. From May to October, until the fruit reaches its normal size, latent *Diplodia* is evenly distributed over all parts of the stem-end. From November to April it is prevalent in the base of fruit and in the receptacle. During March and April it is prevalent in the base of the fruit (fig. 1).

As regards the distribution of total *Diplodia*, the latter was found throughout the season to occur frequently on all parts of the stem-end, and it was prevalent on the sepals.

The infection of flowers

Among 72 flowers, *Diplodia* was found to be present on the sepals in a single instance only. It should be added that in May 1939 *Diplodia* was found once on petals persisting after fruit set. A list of microorganisms found on the flower parts is given in table 6.

The infection of sepals

The study of sepals affected wholly or at their margins as a source of *Diplodia* infection yielded negative results. On sepals from 160 fruits *Diplodia* was found to be present on the margins only twice, in fruits originating from the young grove in March. On the other hand, *Colletotrichum gloeosporioides* and *Alternaria spp.* were almost always present, and frequently *Glomerella cingulata, Macrosporium sp., Pleospora herbarum,* and *Cladosporium herbarum* were also found. The percentage of sepals found affected during February and March is indicated in table 5.

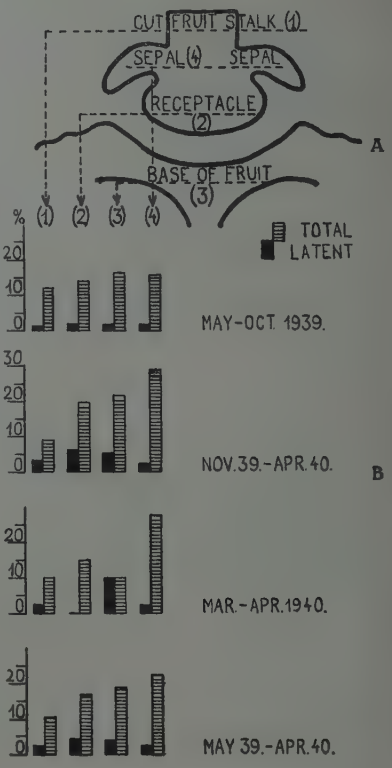


Fig. 1.

A) The division of the stem-end into four parts:

(1) cut stem-end, (2) receptacle, (3) base of fruits and (4) sepals.

B) The incidence of total and latent Diplodia on the different parts of the stem-end of Shamouti orange from fruit set to maturity (Old grove, 1939—40).

TABLE 5.

The percentage of sepals affected entirely or at their margins

Each item 500 fruits.

	2.2.40.	10.3.40.
Healthy sepals	48.6	37.4
Entirely affected sepals	15.0	20.0
Sepals affected at their margins	36.4	42.6

The infection of yellowed or dropped fruits

The study of the role played by pathogenic fungi in bringing about fruit drop in the course of May-October 1939 gave the following results: of the stem-end rot causing fungi, which may develop quickly, *Diplodia* was found only once in August, and *Phomopsis* twice — in May and in October. The majority of dropped fruit was not infected by *Diplodia*, but many cultures yielded other fungi: *Alternaria, Colletotrichum, Coniothecium, Fusarium, Macrosporium* and *Pleospora.*

The flora of the stem-end

A list of fungi found on the stem-end is presented in table 6.

TABLE 6.

List of microorganisms isolated from stem-ends and flowers of Shamouti oranges.

	Stem-ends	Flowers
Acrothecium sp.	+	+
Alternaria sp.	+	+
Alternaria citri Ellis & Pierce	+	
Aspergillus elegans Gasp.	+	
Aspergillus niger Van Tiegh	+	+
Aspergillus terreus Thom	+	+
Bacteria		+
Bispora sp.	+	+
Botryosphaeria ribis Gros. & Dug.	+	
Botrytis sp.	+	+
Caldariomyces fumago Woronichin	+	+
Chaetomium sp.	+	
Cladosporium herbarum Lk.	+	+
Colletotrichum gloeosporioides Penz.	+	+
Coniothecium scabrum McAlp.	+	
Dematium sp.	+	
Diplodia natalensis P. E.	+	+
Dothiorella gregaria Sacc.	+	
Epicoccum neglectum Desm.	+	+
Episporium sp.	+	+
Fusarium spp.	+	+
Glomerella cingulata (Ston.) Spauld & Schrenk	+	+
Helminthosporium sp.	+	+
Macrosporium sp.	+	+
Melanospora destruens Shear	+	
Mucor sp.	+	+
Nigrospora oryzae (Berk. & Br.) Petch	+	+
Penicillium sp.	+	+
Penicillium digitatum Sacc.	+	+
Penicillium italicum Wehmer	+	+
Pestalotia sp.	+	
Phoma sp.	+	+
Phomopsis citri Fawcett	+	
Pleospora herbarum (Pers.). Rabenh.	+	+
Pythium olygandrum Drechsler	+	
Rhizopus nigricans Ehr.	+	+
Saccharomycetes		+
Sporotrichum sp.	+	
Torula sp.	+	+
Trichoderma viride Pers. ex Fr.	+	
Verticillium sp.	+	

SEASON 1940-41

Plan and methods

The results of the previous years' investigations showed that latent *Diplodia* does not occur more frequently on wilted (affected) than on healthy sepals. The period of this year's investigation of sepals was extended and samples of wilted sepals only were cultured every month from December 1940 to April 1941.

As in the preceding years, one of the groves selected was old and known to have a high incidence of diplodia stem-end rot (grove A), while the second grove (B) was young and had a low natural incidence of *Diplodia*. In the earlier part of the investigation the incidence of *Diplodia* in both groves was seen to be equally high; therefore an additional young grove (C) was included in the later part of the season.

Five series of examinations at monthly intervals were carried out with fruits from groves A and B, and two (March and April) with fruit from grove C.

In these series 500 fruits, chosen at random from 50 trees, were examined in the middle of each month. Among the 500 fruits 21-35 fruits with sepals wilted entirely or at their margins were selected for culturing by the methods described above.

The study of the presence of *Diplodia* on orange flowers was continued in this year. In mid-April 1941 24 flowers were selected for culturing in each of the above three groves. The flowers were divided into sepals, ovary, and style with stigma. Cultures were made either with or without previous disinfection.

Investigations on the cause of premature yellowing and dropping of fruit were carried out in this year when the fruit reached almost full size. At that stage dropping may be generally attribued to pathogenic causes.

The yellowed fruits, which were still attached to the tree, were selected and picked with elongated stalks at the end of September 1940, 17 fruits being taken from grove A and 30 from grove B. Cultures were further made from five elongated, dry and brownish stalks of fruits from grove A, and from 7 such stalks from grove B.

Results

The condition of sepals during the season

As shown in table 7 the relative proportion of fruits with sound and wilted sepals in each of the months was very variable in all groves. The average amount of fruit with entirely wilted sepals over the whole season was highest in grove B and lowest in grove C. As regards fruits with sepals wilted at their margins, differences in their frequency distribution in the three groves were not significant.

The incidence of Diplodia on sepals

The incidence of *Diplodia* was observed to be higher in the investigation of this year as compared with previous years. This corresponded with somewhat higher temperatures prevailing during this season. But the principal cause was probably the neglection of orange groves under war-time conditions. The groves also yielded

much more diplodia stem-end rot than in previous seasons (13, 14, 15).

The highest incidence of *Diplodia* on sepals was yielded by grove A in February and by grove B in March; in grove C, where observations were made only twice, the incidence was higher in March than in April. The incidence of *Diplodia* on sepals of either description, i.e. wilted entirely or at their margins, was highest in grove C and lowest in grove A (table 8).

The expected incidence of diplodia stem-end rot in fruit

If an average is taken of the percentage of fruit with affected sepals recorded in each grove over the whole experimental period, and this figure is multiplied by the average percentage of *Diplodia* found on affected sepals (table 7 and 8) in the course of the season, we obtain an approximate indication of the incidence of diplodia stem-end rot in fruit with affected sepals to be expected in each of the groves under investigation (table 9). This expectation was however evidently lower than the actual incidence of stem-end rot in fruits from these groves.

TABLE 7.

Percentage of fruit with sound and wilted sepals or sepals dried at their margins (1940—1941).

(Each item consists of 500 fruits)

Date		Grove A			B			C		
12. Dec. 40.	Sound sepals	73.6			75.4					
	Wilted sepals		7.0			11.0				
	Dried margins			19.4			13.6			
12. Jan. 41.	Sound sepals	56.6			47.6					
	Wilted sepals		6.4			20.8				
	Dried margins			37.0			31.6			
11. Feb. 41.	Sound sepals	73.0			59.0					
	Wilted sepals		7.2			9.0				
	Dried margins			19.8			32.0			
11. Mar.41.	Sound sepals	73.6			71.4			62.6		
	Wilted sepals		14.0			13.6			2.4	
	Dried margins			12.4			15.0			35.0
15. Apr. 41.	Sound sepals	89.2			82.2			91.8		
	Wilted sepals		7.0			11.8			4.2	
	Dried margins			3.8			6.0			4.0
Seasonal Average	Sound sepals	73.2			67.1			77.2		
	Wilted sepals		8.3			13.2			3.3	
	Dried margins			18.5			19.6			19.5

TABLE 8.

Incidence of Diplodia on affected sepals and margins of sepals

Date	Part examined	Grove A		Grove B		Grove C	
		No. examined	Diplodia	No. examined	Diplodia	No. examined	Diplodia
12. Dec. 40.	Sepals	15	0	21	1		
	Margins	6	0	—	—		
12. Jan. 41.	Sepals	12	0	12	1		
	Margins	9	1	9	1		
11. Feb. 41.	Sepals	15	4	21	0		
	Margins	6	1	—	—		
11. Mar. 41.	Sepals	12	1	15	5	9	4
	Margins	6	1	6	2	9	1
15. Apr. 41.	Sepals	25	0	25	2	16	1
	Margins	10	0	10	0	12	0
Seasonal totals and average %	Sepals	79	5	94	9	25	5
	%		6.3		9.6		20.0
	Margins	37	3	25	3	21	1
	%		8.1		12.0		4.8
	Total	116	8	119	12	46	6
	%		6.9		10.1		13.0

TABLE 9.

Expected incidence of diplodia stem-end rot in fruits, calculated from the incidence of Diplodia on affected sepals, and the actual incidence of Diplodia in fruits from the same groves after four weeks' storage at 18°*C* (1940—41).

Grove	No. of fruit examined	% of affected sepals	% of Diplodia	Incidence of Diplodia in fruit	
				expected	actual
A	116	26.8	6.9	1.8	55.0
B	119	32.8	10.1	3.3	—
C	46	22.8	13.0	3.0	18.2

Fungi other than Diplodia found on affected sepals

(a) Fungi known or suspected to be agents of stem-end rot. As apparent from table 10, *Colletotrichum glocosporioides* was prevalent in all groves and, in the case of grove A, was yielded by 83% of the cultured sepals. The perfect stage of this fungus, *Glomerella cingulata*, was abundant in groves B and C, and appeared in about 30% of the cultures.

TABLE 10.

Frequency of occurrence of fungi other than Diplodia on affected sepals and dried margins (1940—1941).

	Grove A		Grove B		Grove C	
	sepals	margins	sepals	margins	sepals	margins
Number examined:	79	37	94	25	25	21
Fungi found:						
Alternaria Macrosporium and *Pleospora*	56	11	33	16	17	10
Colletotrichum gloeosporioides	71	25	47	7	16	14
Glomerella cingulata	—	2	26	10	7	5
Other fungi	14	11	27	4	7	5

The group of fungi comprising *Alternaria, Macrosporium* and *Pleospora* was found to be very abundant, and appeared in about 60% of the fruit from grove C.

(b) Other fungi.

Other fungi isolated from sepals are listed in table 6.

The infection of flowers

Out of 72 flowers examined, *Diplodia* was found on the sepals of 5, on the ovary of 1, and on the style and stygma of 3. Other fungi found on flowers are listed in table 6.

The infection of prematurely yellowed fruit

The incidence of *Diplodia* on fruits prematurely yellowed and about to drop was relatively high in this year's experiment. In samples from grove A (old) the stem-end yielded *Diplodia* in 4 out of 17 fruits, and in those from grove B (young) in 11 out of 30 fruits. The fungus was found in cultures from all parts of the stem-end. The elongated stalks yielded *Diplodia* in 3 out of 7 fruits from grove B only.

Colletotrichum gloeosporioides and *Alternaria sp.* were abundant in all the fruits examined. *Phomopsis sp.* was found only twice on sepals.

DISCUSSION AND CONCLUSIONS

Latent Diplodia and the occurrence of stem-end rot

Reference has been made in the introduction to this paper to numerous investigations indicating that latent infection by *Diplodia* may cause stem-end rot of citrus fruits (8, 17, 18, 21, 22, 23). There is further a rich literature dealing with other fungi causing latent infection of tropical fruits (1, 4, 6, 9, 10, 11, 24). Bartholomew (3) in his comprehensive study on alternaria rot of lemons summarizes the part dealing with latent infection as follows:

The lemon fruits become potentially infected with *Alternaria* before picking but they do not usually begin to decay until after being placed in storage... The removal of the buttons is not effective... Although the button becomes infected while the fruit is very young and spores are also entrapped under the button, it is only in exceptional cases that the *Alternaria* fungus has entered the fruit tissue by the time the lemons are picked. *Alternaria* may enter the lemon directly from the button or from spores or mycelium harboured between the button and the lemon.

While the microtome sections did not show any mycelium in the inner tissue of the stem-end, *Diplodia* spores were found in the axil of sepals or in crevices and depressions near the base of the fruit. Mycelium found within the necrotic tissue of the axil led Nadel (17) to assume latent infection. Simmonds (20) pointed out that the mere isolation of a fungus from surface sterilized fruit does not constitute proof of latent infection, because the proportion of latent infection which develops and causes a ripe rot is probably small. He added that latent infection is proved only if surface sterilization kills all the spore forms.

In our investigation we proved that the surface disinfection of diseased stem-end parts greatly reduced the flora of most fungi usually isolated from citrus fruits, including *Diplodia* and *Alternaria*. On the other hand, certain fungi (*Colletotrichum, Glomerella*) grew in increased numbers after surface disinfection. Without further investigation into the efficacy of the mode of disinfection chosen, we assume that disinfection before plating eliminated the superficial *Diplodia*, and thus favoured the development of the latent *Diplodia* only.

The view of Simmonds (20) that only a small proportion of latent infections will cause rot, and, on the other hand, the high incidence of diplodia stem-end rot occurring in practice, led the author to assume that the cause of the stem-end rot of Shamouti oranges is not latent infection in its strict sense, but what has here been termed "latent *Diplodia*", viz. lodged *Diplodia* spores in the stem-end region and the germinating mycelium which penetrates the fruit still on the tree, as the season advances. This view is supported by our findings indicating the amounts of *Diplodia* present in the base of fruit to increase with the advancing season (table 4).

The presence of *Diplodia* on all parts of the stem-end throughout the period of fruit formation explains the development of diplodia stem-end rot whenever conditions favour its development throughout the picking season. The question now was whether the prevalence of latent *Diplodia* in the stem-end was alone responsible for the rotting of fruits or whether the very great quantities of total *Diplodia* present on the stem-end was also capable, under certain conditions, of penetrating and inducing fruit rotting. A comparison if our results relating to the incidence in two consecutive years of diplodia rot that

developed naturally on fruits from the same old grove stored in both years at 18°C (13, 14) will elucidate this question. In March and April 1939 the percentage of stem-end rot after four weeks' storage at 18°C was 25 and 37 per cent, respectively. In the same year the average amount of latent *Diplodia* on the stem-end in the middle and in the end of March was 36 per cent, while the figure for total *Diplodia* was 73 per cent. In 1940 the average amount of stem-end rot after four weeks' storage at 18°C was 9 percent in December-March, and 15 per cent at the end of March. The incidence of latent *Diplodia* on the stem-end was 12 per cent in November-April, and 12.5 per cent in March-April; total *Diplodia* amounting at the same time to 51 and 37.5 per cent, respectively.

In both years we thus observe a fair relationship between the latent *Diplodia* of the stem-end and the natural incidence of stem-end rot developing in storage at a temperature favourable for the development of *Diplodia natalensis*.

Latent Diplodia and pruning of diseased branches

The pruned trees were located between the bulk of trees left unpruned; the resulting amount of latent *Diplodia* was about equal on the stem-end of fruit from pruned and unpruned trees. The infection probably had its source on the unpruned trees.

The infection of sepals and flowers

The results of the first year's experiment showed that affected sepals do not carry latent *Diplodia* more than healthy sepals; the incidence of total *Diplodia* was however higher on affected sepals and on the stem-end of fruit with affected sepals.

In the second year the examination of infected sepals revealed latent *Diplodia* on the margins only in two out of 160 cases.

In the third year *Diplodia* was present in three different groves in greater abundance, but in a very low proportion to the expected stem-end rot of fruit.

It may therefore be assumed that dried or affected sepals can hardly be considered an important source of diplodia stem-end rot in Shamouti oranges, although in this way rot could be induced in fruit by inoculation (16). It may further be assumed that fungi other than *Diplodia*, i.e. *Colletotrichum* and *Alternaria*, are the cause of the drying of sepals.

The flowers of Shamouti oranges were only occasionally found infected by *Diplodia*.

The infection of prematurely yellowed or dropped fruit

Chaudhuri (6) and Fawcett (7) describe *Alternaria* and *Colletotrichum* as causes of premature fruit drop; in the light of our experiments *Diplodia*, *Colletotrichum* and *Alternaria* could all be the cause of premature yellowing and subsequent dropping of normal sized fruit.

Infection through the cut stem-end

Although the cut stem-end may provide an entrance for the infection of fruit, as found in laboratory studies (16), under natural conditions this mode of infection was not observed.

Diplodia natalensis P. E. may not therefore be considered a mere wound parasite, as suggested by Baker and Wardlaw (2) with regards to *Botryodiplodia theobromae* Pat.

SUMMARY

The results may be summarized as follows:

(1) *Diplodia natalensis P.E.* was found to be present on or in the stem-end as early as two weeks after fruit set (May).

(2) During the entire second period of the investigation, beginning in November, when fruit reached full size, and ending with the picking season in April, the incidence of *Diplodia* was found to be higher than in the first period extending from fruit set in May until and including October.

(3) The incidence of latent *Diplodia* was found to be highest during March and April, towards the end of the picking season.

(4) *Diplodia* was more abundant on the stem-end of fruits from old groves than on that from a young grove.

(5) As regards the individual parts of the stem-end the incidence of latent *Diplodia* late in the season was highest on the base of the fruit, while during the season it was highest on both the receptacle and the base of the fruit.

(6) The incidence of *Diplodia* on the stem-end of fruits from pruned and unpruned trees in the same grove did not differ markedly.

(7) On fruit stored for three days after picking, *Diplodia* was not found to infect the cut stem-end.

(8) The incidence of latent *Diplodia* on wilted or affected sepals of fruit from old and young groves did not exceed that on healthy sepals. However, the incidence of total *Diplodia* on such sepals and on the whole stem-end of fruit with such sepals was higher than with healthy sepals.

(9) The drying of sepals or their margins with the advance of the picking season (February-March) was mostly caused by *Colletotrichum glocosporioides* Penz. and *Alternaria sp. Diplodia* was, however, present at times.

(10) The infection of flowers may be considered negligible, *Diplodia* having been found only occasionally.

(11) The premature yellowing and subsequent dropping of normal sized fruit may not be ascribed to any definite fungus, but

Diplodia, Colletotrichum and *Alternaria* can alike be suspected of being responsible for the phenomenon.

(12) It may be assumed that the cause of diplodia stem-end rot in Shamouti oranges are the spores lodged in the stem-end region, which with the advancing season germinate and penetrate slightly into the tissue of the fruit through its base.

ACKNOWLEDGMENTS

The author is indebted to Dr. I. REICHERT, head of the Division of Plant Pathology, for the critical reading of the manuscript, and to the Imperial Mycological Institute, Kew, for several of the identifications of fungi mentioned in this paper. He further wishes to thank Dr. Mina NADEL who participated in this investigation.

REFERENCES

1. BAKER, R.E.D. (1938). Studies in the pathogenicity of tropical fungi. II. — *Ann. Bot.*, N.S. II:919-931.

2. BAKER, R.E.D., & WARDLAW, C.W. (193). Studies in pathogenicity in tropical fungi. I. — *Ann. Bot., N.S.* I: 59-66.

3. BARTHOLOMEW, E.T. (1926). Alternaria rot of lemons. *Univ. Cal. Agr. Exp. Sta. Bul.* 408, pp. 39.

4. BATES, G.R. (1936). Storage tests with Rhodesian oranges during 1934. — *Brit. S. Afr. Co., Mazoe Citrus Exp. Sta. Publ.* 4b.

5. BATES, G.R. (1937). Diseases of citrus fruits in Southern Rhodesia. — *Brit. S. Afr. Co., Mazoe Citrus Exp. Sta. Publ.* 6c.

6. CHAUDHURI, H. (1936). Diseases of citrus in the Punjab. — *Indian Jour. agr. Sci.*, 6 (part 1) : 72-109.

7. FAWCETT, H.S. (1936). Citrus diseases and their control. — Mc Graw-Hill.

8. FULTON, H.R., & BOWMAN, J.J. (1927). Effect of spraying with fungicides on keeping quality of Florida citrus fruits. — *U.S. Dept. Agr. Circ.* 409.

9. HORNE, W.T. (1934). Avocado diseases in California. — *Univ. Cal. Agr. Exp. Sta. Bul.* 585.

10. HORNE, W.T., & PALMER, D.F. (1935). The control of Dothiorella rot on Avocado. — *Univ. Cal. Agr. Exp. Sta. Bul.* 594.

11. KUNTZ, W.A. (1932). Investigations of stem-end rot of citrus caused by Phomopsis. — *Fla. Agr. Exp. Sta. Ann. Rep.*, p. 145.

12. LITTAUER, F. (1938). Progress report on citrus wastage investigations 1937-38. *Agr. Res. Sta. Rehovot.* Mimeographed.

13. LITTAUER, F. (1939). Progress report on storage, and wastage control experiments with Shamouti oranges, 1938-39. — *Agr. Res. Sta., Rehovot.* Mimeographed.

14. LITTAUER, F. (1940). Progress report on storage, and wastage control experiments with Shamouti oranges, 1939-40. — *Agr. Res. Sta., Rehovot.* Mimeographed.

15. LITTAUER, F., & MINZ, G. (1941). Citrus wastage investigations, 1940-41. — *Agr. Res. Sta., Rehovot.* Mimeographed.

16. LITTAUER, F., MINZ, G., & NADEL, Mina. The mode of infection of fungi pathogenic to citrus fruit. (In print).

17. NADEL, Mina (1944). Anatomical study of the button of Shamouti orange in relation to latent infection. — *Pal. Journ. Bot., Rehovot. Ser.*. 4:166-170.

18. REICHERT, I., & HELLINGER, Esther (1930). Control of Diplodia stem-end rot of Citrus. — *Hadar* 3(6), pp. 14.

19. REICHERT, I. & HELLINGER, Esther (1931). Further experiments on the control of Diplodia stem-end rot of citrus fruits by debuttoning. — *Hadar*, 4(10), pp. 10.

20. SIMMONDS, J.H. (1941). Latent infection in tropical fruits discussed in relation to the part played by species of Gloeosporium and Colletotrichum. — *Proc. Roy. Soc. Qd.* 42:92-120.

21. TISDALE, W.B., & WEST, E. (1934). Certain studies of citrus fruits in storage. — *Fla. Exp. Sta. Ann. Rep.*, p. 77.

22. WINSTON, J.R. (1935). Reducing decay in citrus fruits with borax. — *U.S. Dept. Agr. Techn. Bul.* 488.

23. WINSTON, J.R., FULTON, H.R., & BOWMAN, J.J. (1923). Commercial control of citrus stem-end rot. — *U.S. Dept. Agr. Circ.* 293.

24. Report of the Waite Res. Inst. S. Austr. 1939-40 (1941). Abstract in Rev. Appl Mycol., 21:124, 1942.

BACTERIAL ROT OF AVOCADO FRUIT

By

ZAPHRIRA ELAZARI-VOLCANI

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

(With Plate I)

I. INTRODUCTION

The avocado tree was first introduced into Palestine in 1908. The tree is not yet widely grown in the country. However, quite recently after successful trial, growers became more interested in growing the trees.

Several rots on avocado fruit were recorded in this country. They were mostly caused by fungi, such as *Diplodia sp.* and *Colletotrichum sp.* (1), but no bacterial rot has so far been recorded. In March 1946, a single case of rotting of an avocado fruit has for the first time been found to be associated with bacteria, as described below.

The purpose of this study was to identify this organism and to test its pathogenicity.

We want to thank Dr. S. P. Wiltshire, Director of the Imperial Mycological Institute, London, for securing for us the help of Dr. W. I. Dowson to whom our thanks and gratitude are due for making methodical suggestions and for helping us in the identification of the organism.

II. DESCRIPTION OF THE DISEASE

An unripe, decayed avocado fruit from a seedling tree of the Guatemalan race, was picked from the tree on the 31.3.46 and brought to the laboratory for examination. It showed a hard, dry, greenish rot starting from the distal end, and spreading over one side of the fruit, covering about one third of its size.

A section of the fruit showed the following characteristics. The parenchyma tissue of the infected part appeared to be somewhat harder and far darker in colour than the healthy part. There also appeared to be a distinct darkening of the vessels (see plate I, fig. 1).

Free hand sections stained by Claudius' method were observed under the microscope. They showed numerous bacteria in the parenchyma cells of the infected part, but none in the vessels proper.

III. METHODS

(1) *Staining.* Claudius' method (6) for staining bacteria in tissue was found to give the best results. Gram's staining method for bacteria in tissue did not appear very satisfactory in our case (6).

The following staining methods for the identification of the organism were used: (a) Direct smears from infected parts of the

fruit were stained by Gram (8). (b) Gram stain of organism in culture (8). (c) Fisher and Conn's method for flagella stain (8). (d) Hiss' method for capsule staining (5). (e) Schaffer and Fulton's Modification of Wirtz's method for spore staining (8). (f) Ziehl-Nielsen's Carbol fuchsin for acid fast (8).

(2) *Isolation of organisms.* Pure cultures were isolated from infected parts on potato agar and nutrient agar of pH 7.2 at 25°C.

The method of isolation was as follows: The surface of the infected part of the fruit was sterilized by flaming it over the fire. Small pieces of fruit were taken from underneath that surface with a sterile knife, and were put into a Petri dish containing media.

(3) *Morphological observation.* The organism was measured in 48 hours old cultures grown on nutrient agar at 25°C., stained by Gram. A description of the organism stained by Gram is given at that stage.

(4) *Inoculation of fruits.* The avocado fruits were pricked with a needle: (a) on the distal end and around it; (b) on the stem, before inoculating with a distilled water suspension of the organism grown in nutrient agar. The same method of inoculation was applied on unpricked fruits; (c) at the distal end, (d) at the stem. In all cases the fruits were kept in inoculating chambers, consisting of dishes covered with glass jars in which humidity was kept up by introducing small beakers filled with distilled water. The citrus fruits were (e) covered in various places with drops of a broth culture of the organism, and the rind was pricked through the drops, (f) the fruits were pricked in different places and sprayed later with a broth culture of the organism. The same treatment was also applied to the control fruits, but sterile distilled water was used instead of the suspension and broth culture of the organism.

IV. DESCRIPTION OF THE ORGANISM ISOLATED FROM THE ORIGINAL FRUIT

Morphology. 48 hours old culture grown on nutrient agar at 25°C., gram stain: short rods almost pointed at the ends. 0.3 to 0.6 by 1.6 to 2.4 microns, occurring singly and in pairs. Motile by means of lophotrichous flagella; often monopolar with 2 flagella, sometimes bipolar with 2 or 3 flagella (see plate I, fig. 5); Gram negative, capsulated, aerobe and facultative anaerobe. Optimum growth at 23°-30°C. Maximum temperature 35°C. Minimum temperature 5-6°C. The thermal death point is approximately 50°C.

Green fluorescent pigment produced in culture.

Agar colonies. Circular, amorphous, moist, cream-white, entire margin, slightly convex with a flat halo which tends to become slightly undulate in older cultures.

Very tiny transparent colonies appear 24 hours after inoculation. 48 hours after inoculation they become distinctly cream-white. The medium was unchanged in colour, and there was no particular odour.

Growth on nutrient agar and potato agar (pH 7.2) quite profuse at 25°C.

Glucose Agar — appearance of colonies as described above.

Agar slant — moist, cream-white.

Agar streak — echinulate.

Agar stab — Best growth on the surface. In a two weeks' culture a circular, slightly raised, cream-white colony about 5 mm in diameter had developed on the surface around the stab, and slight echinulate growth had taken place along the upper part of the stab.

Broth — turbid colour, very thin pellicle appears 4 days after inoculation.

Potato slant — cream-white, a slight brownish tinge appears in approximately 10 days old cultures.

Gelatine — liquefied, slow liquefaction, positive results on Difco-Nutrient Gelatine.

Starch Agar (consisting of meat extract 0.3%, agar 2%, soluble starch 1 gr. treated by iodine 5 days after inoculation) — not hydrolyzed; but weakly hydrolyzed when 0.2% soluble starch instead of 1%, is used and the iodine is added after removing the growth from the agar.

Purple milk — no coagulation. Milk did not clear. There was no apparent change in purple milk up to the 6th, 7th day. On the 8th day it became alkaline.

Nitrates — very slightly reduced, if at all.

Indol — not formed.

Lead acetate — H_2S not formed.

Sugar Fermentation. Durham tubes with media consisting of 1% of the various sugars in nutrient broth were used. Glucose, sucrose, and xylose were reduced to acid without formation of gas. Galactose was slightly reduced without formation of gas. Glycerol and mannitol were also slightly reduced to acid without formation of gas, when synthetic carbohydrate media were used (9), but not when nutrient broth was used as the basal medium.

Synthetic media. Good growth in Uschinsky's solution. A greenish colour appears approximately 48 hours after inoculation. A white colour sediment is formed on the bottom of the tube later on. There is no growth in Cohn's solution.

Sun light sensitivity — feeble.

The examination of the organism has proved that it corresponds very closely with *Pseudomonas syringae* (Van Hall) Bergey et al. of which it might be a local variety.

V. EXPERIMENTS

A. First series

In order to ascertain whether the organism isolated could be the cause of the above-mentioned rot, an inoculation of the organism on healthy unripe fruits was carried out at room temperature which varied between 18 (at night) to 25°C. (at day-time) from the 6.4 46 until the end of the experiment on the 30.4.46.

Inoculation was carried out on two varieties of avocado fruits, the Seedling of Guatemalan race and the Nabal variety. In each case 4 fruits were used for inoculation by the methods mentioned above.

(a) *Fruits pricked at the distal end.*

THE SEEDLING OF THE GUATEMALAN RACE. The unripe fruit, when inoculated after pricking of its distal end, showed rather a quick spreading of infection over fairly large areas including the pricked area as well as some distance below and above it. Three days after the inoculation was effected, the area around the punctures began to turn dark brown, and reached a diameter of 4 mm. These dark spots spread, and 7 days after the inoculation many of them coalesced. The fruit was quite hard and unripe 10 days after inoculation. It showed symptoms similar to those described above for the original specimen. Four days later it still showed the original picture of a hard dark greenish rot at the distal end of the fruit. The fruit remained hard for 18 days, and when cut showed the characteristics described in the original specimen. The fruits started to soften about 20 days after inoculation, and became quite ripe four days later. The infection did not spread to the proximal end. It covered about a third of the fruit and did not progress any further even 4 weeks after inoculation.

In free hand sections stained by Claudius' method, numerous bacteria were observed in the parenchyma cells, but none in the vessels proper; this agrees with our observations in the original sections.

THE NABAL VARIETY. This variety showed more resistance to the infection. Dark brown spots were observed around the punctures 4 days after inoculation, but the infection progressed at a slower rate than in the Guatemalan Seedling. The spots around the punctures did not seem to coalesce all over the pricked area, and did not cover a great surface of that area. However, the same black-greenish colour as well as the hard, dry rot described for the original specimen was observed on infected parts of the inoculated fruit.

The same characteristics as those described in the original specimen were observed in the fruit when cut and in microscopical sections of its infected parts.

(b) *Fruits pricked at the stem.*

No infection was observed either in the Seedling of the Guatemalan race or in the Nabal variety.

(c) and (d) *Unpricked fruits inoculated at the distal end and the stem.*

No infection was observed either in the Guatemalan Seedling or the Nabal variety.

The control fruits remained healthy throughout the experiment. They started to soften 20 days after the start of the experiment, and became quite ripe 4-5 days later.

Pure cultures from infected parts of all the inoculated fruits were isolated on potato and nutrient agar as described above. The examination of the organism isolated from the inoculated parts, proved that it was identical with the one isolated from the original specimen.

B. Second series

A new series of inoculations was carried out on the 21.8.46 on a summer variety of Avocado fruit.

Eight hard and unripe fruits of the Ganther variety were inoculated by the method described under (a). The fruits were kept in inoculating chambers at 25°C-26°C, which was found to be within the optimal range of temperature for the growth of the organism.

The fruits inoculated by pricking at their distal end showed a very quick spreading of infection over fairly large areas. In one case, infection was spreading all over the pricked area already on the second day after inoculation. On the third day almost half of the fruit became dark brownish green, and, when cut longitudinally, showed a distinct darkening of the parenchyma tissue spreading over half the size of the fruit. There also appeared to be a darkening of the vessels all along the fruit.

In all the other fruits, the infection spread all over the pricked area producing a light brown greenish colour of that area on the third day after inoculation. On the 4th day, the colour of the pricked area became much darker, and infection spread below and above that area for about 0.5 cm (see plate I, fig. 2). 8 days after inoculation, about half the surface of the fruits showed the characteristic dark brown-greenish colour of the infection. 2 days later one sample showed a complete darkening of the whole surface of the fruit. The fruits were cut, and sections and isolations of the organism were made on N.A., on the 2nd, 4th, 5th, 6th, 9th, 10th, 14th days after inoculation. Thus 2 fruits only remained under observation for about 2 weeks. The fruits, in contrast to the winter variety, did not remain hard for more than 5 days. They started to soften on the 6th day after inoculation, and became quite ripe about 4 days later.

Sections of the various fruits at different times after inoculation showed a picture very similar to that described for the original specimen and for the first series of inoculation (see plate I, fig. 3), with the sole exception that the former ones, when cut 6 or more days after inoculation became rather soft, whereas in the original specimen as well as in the first series of inoculations, the fruits remained hard for a longer time. All the inoculated fruits, when cut, showed a darkening of the parenchyma tissue of the infected part, as well as a very distinct darkening of the vessels. In some cases, the parenchyma tissue was infected as far as half the size of the fruits. But whilst the other half of the parenchyma tissue appeared to be healthy, the vessels became distinctly dark all along the fruit. In 2 cases only, where the fruits were kept 14 days, the parenchyma tissue as well as the vessels appeared to show the characteristic darkening all along the cut surface of the fruits.

Free hand sections from infected parts taken on successive days in the manner mentioned above and stained by Claudius' method revealed numerous bacteria in the parenchyma cells of the infected parts, but none were found in the vessels proper. In our numerous sections (45) bacteria were found only in three cases in a xylem cell accompanying the vessel.

A direct smear of all infected samples revealed the presence of numerous bacteria.

Pure cultures were recovered from all infected fruits on nutrient agar at 25°C. The growth was profuse.

The control fruits remained healthy throughout, but a distinct softening of the fruits started on the 5th and 6th day after the start of the experiment. The fruits became ripe about 4 days later.

When healthy, unripe, hard fruits were cut, the vessels appeared darker in colour than the parenchyma but never as dark as in infected fruits, whilst in ripe, soft, healthy fruits the vessels had a distinct dark colour, almost as dark as in infected fruit.

The examination of the organism isolated from the inoculated fruits, proved that it was identical with the one isolated from the original fruit.

C. Third series

On the evidence that the isolated organism was very closely corresponding with *Ps. syringae,* and in order to try and produce black pit on the fruits, and thus to prove once more its identity with this pathogen, inoculation of the organism on healthy green and semi-yellow citrus fruits was carried out on the 17.12.46.

Four orange fruits of the Shamouti variety and 4 lemon fruits of the Eureka variety were inoculated, by the methods described under (e) and (f), respectively. An average of 10-15 punctures was

Fig. 1



Fig. 2



Fig. 3



Fig. 4



Fig. 5

made in each case. The fruits were kept in inoculating chambers, at two different temperatures, viz. 14.5°C to 16°C and 17°C to 18.5°C. 4 fruits were kept at each temperature, and each fruit was treated on one side by the method described under (e) and on the opposite side by the method described under (f).

Positive results were obtained on all the inoculated fruits. Typical black pit lesions developed on the inoculated orange and lemon fruits. But whereas the lesions on orange fruits were larger and appeared as slightly sunken light greyish brown, dry, spots with a reddish tinge which did not penetrate into the inner rind, the lesions on lemon fruits were smaller and appeared as deeply sunken, grey-black, dry spots, which penetrated into the inner rind up to half its depth. In neither case did infection spread into the flesh of the fruit, and the spots were softer than the healthy part up till the 12th day after inoculation. Thereafter the lesions on lemon fruits hardened, whilst those on oranges remained somewhat softer.

The control fruits remained healthy and did not show any lesions, apart from the fruits kept at 17°C to 18.5°C, where a very slight change in colour to light grey was apparent around the punctures, but did not progress any further. The progress of infection in inoculated fruits treated by the method described under (e) at temperatures of 17°C to 18.5°C was as follows:

Orange fruits. — Watery, light brown greyish tiny spots appeared around the punctures already on the first day after inoculation. They reached a diameter of 1-2 mm on the second day after inoculation and became slightly sunk. On the third day the slightly sunken brown greyish spots reached a diameter of 2-3 mm, lost their watery appearance, and became softer than the healthy part of the fruit. On the fourth day they appeared as rather dry lesions which reached a diameter of 4-8 mm and their colour became brown-greyish with a reddish tinge. On the 6th day after inoculation there was no change in colour, the spots were slightly sunken, dry and soft, and reached a diameter of 8-12 mm. Some of the spots coalesced. On the 7th day, there was no noticeable change in the size of the lesions, but their colour darkened. On the 8th day the lesions appeared as rather soft, dry, grey brown-reddish slightly sunken large spots of a diameter of 8-12 mm. On the 9th and 10th day there was an increase of ½ to 1 mm in size, especially among the hitherto coalesced spots which formed 2 large stripes almost touching each other. The lesions appeared as slightly sunken, dry spots and stripes which were grey brown with a reddish tinge in the middle and more markedly reddish in their outer part; they were softer than the healthy part of the fruit.

Lemon fruits. — The green and semi-yellow fruits showed dark tiny spots around the punctures already on the first day after inoculation. On the second day the spots were slightly sunken and their

colour became light brown to grey. They reached a diameter of 2-3 mm on the third day after inoculation and were then slightly soft and dry. On the fourth day after inoculation the lesions were more deeply sunk, and their colour became darker. They reached a diameter of 4-8 mm. On the 6th day, the spots were dry, deeply sunk, their colour was grey black, and they reached a diameter of 5-10 mm. Some of the spots were coalescing and formed a stripe of sunken, almost black, dry lesions (see pl. I, fig. 4). On the 7th day after inoculation there was no noticeable change in colour or size. On the 8th day, there was likewise no apparent change in colour and size; the grey-black, dry, deeply sunken spots were softer than the healthy parts of the fruit which were quite hard. On the 9th and 10th day after inoculation there was no change in the size of the spots. The lesions appeared as rather deeply sunken dry spots, and as coalesced stripes, which were quite black in their outer part and rather grey-black in their inner part. They were softer than the healthy part of the fruits. On the 12th day after inoculation the lesions appeared as before except that they became almost as hard as the healthy part of the fruits.

The average size in millimeters of the spots developing during a period of ten days after inoculation, at temperatures of 14.5°C to 16°C. and 17°C to 18.5°C, respectively, on fruits treated by the methods described under (e) and (f), is shown in the following tables.

Size of black-pit lesions (in mm.) at two different temperatures on fruits inoculated in two alternative ways

Temp. °C	Number of days after inoculation									
	1	2	3	4	5	6	7	8	9	10
1. *Fruits pricked through drops of broth cultures*:										
Oranges										
14.5-16	-	0.5	1.5	4.5	6.0	8.0	8.0	8.5	8.5	8.5
17-18.5	1.0	1.5	2.5	5.6	7.0	10.0	10.0	10.0	10.5	10.5
Lemons										
14.5-16	-	0.5	1.5	4.0	5.5	6.0	6.0	6.0	6.0	6.0
17-18.5	0.5	1.0	2.5	5.5	6.5	8.5	8.5	8.5	8.5	8.5
2. *Fruits pricked and sprayed with a broth culture*:										
Oranges										
14.5-16	-	-	0.5	1.0	2.5	6.0	6.5	7.0	7.0	7.0
17-18.5	-	0.5	1.5	3.0	4.5	7.0	7.0	8.0	8.5	8.5
Lemons										
14.5-16	-	-	0.4	1.0	1.3	2.5	4.5	4.5	4.5	4.5
17-18.5	-	0.5	1.5	2.5	4.0	5.5	6.5	6.5	6.5	6.5

In fruits where the rind was pricked through drops of a broth culture of the organism, both on oranges and lemons, the progress of infection was more rapid, and the size of lesions slightly bigger,

than in those which were treated by spraying the broth culture after puncturing the fruits. In both orange and lemon fruits, when treated by the same method and kept at a temperature of 17°C to 18.5°C, infection progressed more rapidly and the lesions were bigger than in those kept at a temperature of 14.5°C to 16°C.

Pure cultures from infected parts of the inoculated orange and lemon fruits were isolated on nutrient agar.

The examination of the organism recovered proved that it was identical with the one isolated from the original specimen.

VI. HISTOLOGICAL PATHOLOGY

The important points to be ascertained in the histological pathology of the above mentioned bacterial disease were: (1) whether the darkening of the vessels was due directly to the occurrence of bacteria in the vessels, (2) whether the bacteria are to be found in the xylem cells accompanying the vessels, (3) whether the darkening is a natural ripening phenomenon and (4) what part of the fruit is harbouring the bacteria.

Dealing with each of these points in turn, we find:

(1) All the examinations of numerous sections of infected and non-infected fruits, showed that bacteria never occurred in the vessels of the infected parts of the fruits. (2) In most cases no bacteria were found even in the xylem cells around the vessels. Only in 3 cases, out of 45, were bacteria found in a single cell of the xylem around the vessel. (3) It was found that darkening of the vessels is a natural phenomenon of mature fruits. Unripe fruits do not normally show a distinct darkening of the vessels. However, infection seems to bring about a change in this respect by a) causing darkening of the vessels to occur in unripe infected fruits, b) causing the darkening of infected mature fruits to be more intensive than the natural darkening of healthy, ripe fruit. (4) The examination of numerous sections showed that bacteria were found only in parenchyma cells, with the rare exception of their occurrence in single cells of the xylem around the vessels. The disease thus spreads through the parenchyma tissue, and the more intensive darkening of the vessels is probably due to the far reaching influence of the infected parenchyma.

VII. DISCUSSION

In this study the first important point to determine was the cause of the fruit rot, i.e. whether the disease was caused by a parasite or not. By the experimental work described above, direct smears, sections, isolations, inoculations and reisolations, it was clearly proved that the causal organism is a bacterium.

In phytopathological literature there is only one bacterial disease which is known to occur on avocado, viz. the so-called Citrus Blast (4) caused by *Pseudomonas syringae* (Van Hall) Bergey et al. (1). Our bacterium, as shown above, corresponds very closely with *Pseudomonas syringae*. However, it differs very slightly in one or two points from the description given for the latter. Thus the colour of the colonies indicated for *Ps. syringae* is greyish-white with a bluish tinge while that of our organism is cream-white. A very distinct and definite difference further exists in the external appearance of the disease on our specimen as compared with that described by W. T. HORNE (4). This author states that citrus blast on avocado usually appears as spots of dead tissue. Sometimes the fruits show areas entirely crusted over by confluence of dead spots and with characteristic cracking which suggests carapace spot. The Palestinian variety of *Ps. syringae* isolated from avocado fruit rot, causes a hard dark-greenish rot which is continuous and penetrates deep into the parenchyma tissue. We never noticed a prominent crust or cracking. On the other hand, our organism produced a very characteristic black pit on orange and lemon fruits quite similar to that described by FAWCETT (3), thus proving its very close relation to *Ps. syringae*. Our organism may thus be considered a local variety of *Ps. syringae*. The host range of this organism and other characteristics are now under investigation.

Since our intention was to prove the identity of our organism with the citrus blast organism, our experiments were mostly limited to that aspect. Although our data are not yet complete it may be of interest to compare them with data given by C. O. SMITH and H. S. FAWCETT (7).

Comparing our results with the average diameter of spots produced by inoculation on lemon fruits with the Californian Avocado strain of *Ps. syringae* at the temperatures used by us, i.e. 14.5°C to 16°C and 17°C to 18.5°C, the following point may be worthy of mention: The size of the spots in California was bigger at 17.4°C-18.5°C than at lower temperatures (13.1°C-17.4°C), and this agrees exactly with our results.

Comparing our results on the optimal range of temperature for the growth of the organism on media as well as the temperature at which the maximum size of colonies was attained, with data given by these authors, the following differences are observed: The range of the optimal temperature for the Californian strain was between 21.4°C to 31.5°C, with 21.4°C giving the maximum size of colonies whereas in our case it was between 23°C to 30°C with 27.0-28.5°C giving the maximum size of colonies. Thus the range of the optimal temperature in our case starts at a somewhat higher level, and the maximum size of colonies is attained at markedly higher temperatures.

VIII. SUMMARY

A dry rot occurring on unripe avocado fruit, not hitherto described in Palestine, was found in March 1946. The features of the rot were: A dry, greenish, dark rot starting at the distal end of the fruit and spreading over one side of the fruit, covering about one third of its size.

Histological examination, cultural isolation, inoculation and re-isolation showed definitely that the rot was caused by a bacterial organism. This organism is easily isolated on nutrient agar, and forms cream-white colonies; it is a white, short rod, Gram negative, and is motile by mono- or bipolar flagella. Gelatine is liquefied, milk becomes alkaline, without coagulation, nitrates are very slightly reduced, if at all. Acid is produced without formation of gas from glucose, sucrose, xylose, and slightly from galactose, glycerol and mannitol, but not from lactose, or maltose. Optimum growth was made at 23°-30°C. The thermal death point is approximately 50°C. The organism was found to correspond very closely with *Ps. syringae* which is the causal organism of Citrus blast and Black pit, and is known to cause an avocado fruit disease. Whereas typical Black pit was produced by our organism, the external appearance of the disease on avocado fruit, as well as the fact of its spreading deep into the parenchyma tissue, differ distinctly from the description given so far in literature. It is assumed that the organism represents a local variety of *Ps. syringae*. In inoculation tests infection has been obtained by two methods. It is evident that the disease is spreading from the distal end downwards through the parenchyma tissue. Although intensive darkening of the vessels is caused by the organism, bacteria were not found in the vessels themselves, but only in the parenchyma tissue.

REFERENCES

1. Bergey, D. H., Breed, R. S., Murray, E. G. D., Parker-Hitchens, A. (1939). Bergey's manual of determinative bacteriology. A key for the identification of organisms of the Class Schizomycetes. Williams & Wilkins Co., Baltimore.

2. Chorin, M. Diseases of subtropical trees. In print.

3. Fawcett, H. S. (1926). Citrus diseases and their control. p. 443-453. McGraw Hill Book Company, Inc. New-York and London. pp. 552.

4. Horne, W. T., (1934). Avocado diseases in California. *Univ. California, Agr. Exp. Sta., Berkeley, Bull.* 585, *pp.*12.

5. Salle, A. Y. (1939). Fundamental principles of Bacteriology, p. 77, McGraw Hill Book Company. Inc., New-York and London, pp. 618.

6. Schneider, H. Z., & Zimmermann, A. Die Botanische Mikrotechnik, p. 393-4, Jena, Verlag von Gustav Fischer, 1922. pp. 458.

7. SMITH, C. O. & FAWCETT, H. S. (1930). A comparative study of the Citrus Blast Bacterium and some other allied organisms. *Journ. of Agric. Res.* 41(3): 233-246.

8. Manual of Methods for Pure Culture Study of Bacteria. Society of American Bacteriologists (1943), Leaflet IV, Staining, 8th edition, May, 1943.

9. Manual of Methods for Pure Culture Study of Bacteria. Society of American Bacteriologists (1944). Leaflet II, Media. 9th edition, April, 1944.

EXPLANATION OF PLATE I.

Fig. 1. Longitudinal section of a piece of infected, unripe avocado fruit (original specimen), showing darkening of the parenchyma tissue.

Fig. 2. Inoculated avocado fruit showing the spread of the disease on the 6th day after inoculation.

Fig. 3. Longitudinal section of inoculated, unripe avocado fruit showing darkening of the parenchyma and vessels.

Fig. 4. Inoculated lemon fruit showing Black-pit lesions on the 6th day of the inoculation.

Fig. 5. Cells showing polar and bipolar flagella, stained by Fisher and Conn's method (×1200, ×1600, respectively).

POWDERY MILDEW ON THE LEAVES OF *DODONAEA VISCOSA* LINN.

By TEMIRA VOLCANI

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

In March 1945 shrubs of *Dodonaea viscosa* Linn. bordering the drive of the Agricultural Research Station at Rehovot, in the central coastal plain of Palestine, were found to have some of their leaves affected by a powdery mildew. This paper is to describe the results of a closer examination of the disease and its causal agent and of some experimental work on the biology of the latter.

DESCRIPTION OF THE DISEASE

Development of the disease was found to begin on the upper side of the leaves. Here white and powdery growth first appears, bearing slender, radially branched threads. This growth may be limited in extent or may cover large parts, or even the whole, of the leaf blade as the season advances into July. The parts covered by powdery mildew turn first light mauve and afterwards brown-black in colour. These spots are sometimes also apparent on the lower side of the leaf, where first the veins and then the whole area corresponding to the spot on the upper side turn black. But frequently no disease symptoms at all are to be found on the underside of the leaves. The white growth on the spots is denser in their centre than near their periphery, where threads may be sparsely distributed or few in number.

Leaves severely affected by the disease yellow and shed. As the lower leaves are the first to be affected, they are also the first to shed.

Microscopic examination of affected leaf tissues showed large numbers of conidia borne in chains on conidiophores arising from a mycelium that creeps along the leaf surface and projects haustoria into the epidermal cells.

THE FUNGUS

The conidiophores are hyaline and bear chains of 4-6 hyaline spores. The chains measure 66-105μ in length. The foot of the sporophore is narrower than the chain of spores. Measuring 25 sporophores we found their length to range from 45 to 90μ, mostly 60μ, the width of the foot being 9-12μ.

The spores are cylindrical in shape. When 100 mature spores that had shed from their chains and were taken from different spots were measured, their length was determined to be 24-33μ, mostly 27-30μ, and width 12-15μ, mostly 15μ.

The superficial mycelium is also hyaline, the hyphae measuring 5-6μ in width (25 measurements). The mycelium does not penetrate the leaf through the stomata but develops on its surface and gives rise to narrow tubes passing through the cuticle into the epidermal cells. This tube is 1.75μ wide and 3.5-5μ long, and suddenly widens in the epidermal cell into a hyaline haustorium shaped like an egg or like a sausage straight or bent in the middle. The shape of the haustoria may sometimes be irregular. Their length amounts to 10.5-24.5μ, chiefly 14-17.5μ, and their width to 7-12μ. The slender tube penetrating the epidermal cell, before it swells into a haustorium, measures 3.5-10.5μ, mostly 3.5μ, in length, and is 1.75μ wide (25 measurements).

As the perfect stage of the fungus has not been found, we are unable to determine the genus to which this powdery mildew belongs. We are not aware of any literature reference to this fungus on *Dodonaea* and consider it therefore as a new species under the nome of *Oidium dodonaeae* I. Reichert et T. Volcani.

OIDIUM DODONAEAE I. Reichert et T. Volcani.

Maculis epiphyllis, late efusis, arachneo-pruinosulis, radialibus, albidis; hyphis sterilibus repentibus, ramosis, 6-8μ crassis, hyalinis; fertilibus erectis, 0-2 articulatis, albidis, haustoriis ovularis-allontoidis praeditis; conidiis catenulatis, cylindraceis, 25-35×10-15μ, hyalinis, eguttolatis.

GERMINATION TESTS

Spores of *Oidium Dodonaeae* were germinated (a) on slides and (b) on leaves of *Dodonaea*.

It was found inconvenient to use for this purpose naturally infected leaves collected out-of-doors, because these leaves were very dusty. A "pure culture" was therefore first prepared on leaves in the laboratory and this was used to supply the spores for our tests.

(a) *Germination on glass slides.*

Dry cover glasses were placed on glass rings attached to slides. A drop of water was placed on the bottom of the chamber thus formed. Spores were germinated after being stirred in the water with a glass rod, or on dry cover slips. The tests were carried out in 3 series (10 and 11 November 1945, 8th January 1946) in a total of 9 replicates. Spores germinated only on dry glass, never in drops of water. The failure of spores to germinate in water is well-known in the case of various powdery mildews (2, 3). Germination began after 3-4 hours. The percentage of germination rose from hour to hour and, after 24 hours, ranged from 24 to 82 percent.

(b) *Germination on leaves.*

Fresh leaves of *Dodonaea* were rinsed with sterile water and were dusted with spores. These tests were carried out in March and November 1945 and in January 1946, in a total of 9 replicates. Spores

were applied to some leaves on their upper, to others on their lower surface. In addition, we attempted to germinate spores from *Dodonaea* leaves on carob leaves. These were chosen because carob tree growing nearby were severely infected with a powdery mildew.

The results showed that the spores germinated on the upper as well as the lower side of *Dodonaea* leaves. Differences in the germination on either leaf surface could not be observed because the greater part of the spores fell from the leaves, and records of the rate and percentage of germination failed for the same reason. The few spores persisting on carob leaves did not germinate.

INOCULATION TESTS

Young *Dodonaea* leaves and old leaves free from mildew were rinsed with sterile water and were then inoculatd, some from their lower, some from their upper surface, with spores obtained as described above. The point of inoculation was marked by a circle of printer's ink.

The leaf stalks were placed in Petri dishes the bottom of which was covered with moist filter paper. The dishes were placed on plates likewise lined with moist filter paper and covered with bell jars. The moisture level was maintained by adding sterile water at intervals of one or two days. The leaves were in this way kept fresh and moist throughout the test, for periods up to and even exceeding two months.



Fig. 1. Infection of the lower leaf surface of *Dodonaea* leaf. The hyphae branch, form haustoria in the epidermal cells, but do not penetrate through stomata.

Two inoculated leaf segments were cut off for each of the examinations made at fixed intervals. Chlorophyll was extracted from the leaves by the alcohol heating method as described by Aronescu (1). The penetration of the fungus into the cells of the leaf could thus be observed from above without sections being made. After this treatment the segments were placed in Blue Cotton solutions, were heated, placed on slides and prepared for microscopic examination. The fungal tissue was stained by Cotton Blue, while the host tissue remained unstained.

Observations covered germination of spores and development of mycelium and haustoria (cf. fig. 1).

Inoculations tests were also made with powdery mildew from carob leaves on *Dodonaea* leaves and with powdery mildew from the latter on carob leaves.

RESULTS. Young leaves were found more suitable for these tests because the mildew spores adhered better to them and they kept fresh under the bell jars longer than old leaves.

As mentioned above, spores germinated on both the upper and the lower surface of *Dodonaea* leaves, but germination on the upper side was apparent after one day and on the lower side only after 2 days. Conidiophores already developed on the upper side after 8 days, while we did not succeed in determining the period required to this end on the lower side.

On the upper side of the leaf white growth was apparent in many places about 14 days after inoculation, while on the lower side isolated white spots could be observed only after one month.

The germinating tube was observed not to penetrate through the stomata. Even where spores germinated close to stomata, the penetrating tube did not in any way turn towards them. In this connection we may also note that the upper leaf surface with its smaller number of stomata was more severely affected than the lower leaf surface where stomata are more abundant.

Haustoria were observed 6 days after inoculation. The number of haustoria increased progressively, and on leaves wilting owing to mildew attack haustoria could be observed in almost every epidermal cell.

Perithecia failed to form on inoculated leaves or on naturally infected leaves kept for 4 months in the laboratory in a moist chamber or under dry conditions.

The inoculations of powdery mildew from *Dodonaea* on carob leaves, and conversely inoculation of *Dodonaea* leaves with powdery mildew from carobs, gave only negative results.

SUMMARY

A newly recorded powdery mildew disease affecting the leaves of *Dodonaea viscosa* has been described. The causal agent has been named *Oidium Dodonaeae* I. Reichert et T. Volcani n. sp.

Spores of the powdery mildew were found to germinate on either side of *Dodonaea* leaves, but infection was more rapid and virulent on the upper than on the lower side.

The morphology of the various parts of the fungus and the mode of its penetration into the leaves has been described.

Inoculations of carob leaves with mildew from *Dodonaea*, and of *Dodonaea* leaves with mildew from carobs, were unsuccessful.

REFERENCES

1. Aronescu, A. (1934). Diplocarpon Rosae: from spore germination to haustorium formation. *Torrey Bot. Club.* 61: 291-329.

2. Blumer, S. (1933). Die Erysiphaceen Mitteleuropas mit besonderer Berücksichtigung der Schweiz. — *Beitr. zur Kryptogamenflora der Schweiz,* VII, 1. 483 pp.

3. Longree, V. (1939). The effect of temperature and relative humidity on the powdery mildew of roses. *Cornell Univ. Agr. Exp. Station, Mem.* 223.

POTATO BLIGHT CONTROL IN PALESTINE

By F. LITTAUER, J. PALTI and S. MOELLER,

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

		Page
I.	Introduction	186
II.	The occurrence of *Phytophthora* blight in Palestine	187
III.	The occurrence of *Alternaria* blight in Palestine	188
IV.	Blight control trials	188
V.	Summary	199
	References.	200

I. INTRODUCTION

Phytophthora and *Alternaria* blights of potatoes are of widespread occurrence in most of the potato growing districts of Palestine. The two diseases differ considerably in the regularity of their appearance and in their destructiveness. *Phytophthora* blight does not appear regularly; the disease may attack the crop at any stage of growth and is most commonly found early in the growth of winter-sown crops. The designation "late blight", which is commonly used for this disease, thus does not apply in this country. *Alternaria* blight, on the other hand, rarely fails to appear on potato crops grown at any season of the year, but usually assumes epidemic form only shortly before the crop is lifted. Pittman (9) made similar observations regarding this disease in Western Australia and concluded that the name of "early blight", under which the disease is generally known, is a misnomer; this conclusion is equally valid under Palestinian conditions. We shall therefore refer to the two diseases in question as *Phytophthora* blight and *Alternaria* blight.

The purpose of this paper is to sketch the seasonal and regional distribution of the potato blights in Palestine and to report on the first spraying trials carried out in this country for the control of these diseases over a period of three years (1941-1943).

In Palestine, potatoes are usually sown at three successive seasons, viz. in August-September (autumn sowing) to be lifted in December, in December (winter sowing) to be lifted in April, and in February-March (spring sowing) to be lifted in May-June. The rainy period normally extends from November to March. In the spring and autumn crops irrigation is necessary throughout the growing season, in the winter crops only at the end of the season.

II. THE OCCURRENCE OF *PHYTOPHTHORA* BLIGHT IN PALESTINE

The blight caused by *Phytophthora infestans* (Mont.) de Bary has been known to attack the leaves and stalks of potatoes ever since this crop began to be grown in Palestine on a larger scale, in the early twenties of this century. At that time imports of potato seed tubers from European countries were made every year, and such tubers were often markedly infected by *Phytophthora*. Until 1935 the disease never assumed epiphytotic proportions, but in winter 1935/1936 serious losses were for the first time sustained by its attack(3). Thereafter, *Phytophthora* blight was little in appearance for a period of seven years. In 1942/1943, however, severe losses were caused by a widespread epiphytotic of blight, and considerable damage was likewise caused in 1943/1944.

Phytophthora blight most commonly occurs on winter and spring sown potatoes and its spread is generally most rapid from December to early April. With the onset of the period of dry, hot winds (khamsins), mostly in April or May, conditions tend to become unfavourable for the disease. However, after this period has passed, renewed, though weaker, attacks of the blight are not infrequent in late May and June. *Phytophthora* blight has so far only once been known to attack the shoots of autumn sown potatoes, viz. in November 1942, after unusually early winter rains.

In winter and early spring *Phytophthora* blight occurs in almost all the settled parts of Palestine, all along the coastal plain, in the Valley of Esdraelon and the Jordan Valley, and in the Upper and Lower Galilee. In late spring and early summer, attacks are usually confined to parts of the coastal plain, especially the northern Sharon between Tel Aviv and Hadera, possibly because early morning mists are frequent in this region.

The presence of *Phytophthora* on locally grown potato tubers was first established in Palestine in 1942/1943. Autumn sown crops lifted in December then developed a moderately high percentage of tuber rots, after the haulms had been severely attacked by *Phytophthora* blight. In 1943/1944 considerable infection of the yield lifted in December was also noted, although no symptoms of blight had been in appearance on the shoots. Potato tubers lifted in spring or early summer have not so far been found to contract infection by *Phytophthora*.

Although accurate data on varietal resistance to *Phytophthora* blight under Palestinian conditions are not yet available, we may safely say that of the principal varieties grown here Up-to-Date and Epicure are highly susceptible, while Arran Banner, Kerrs Pink and Doon Star are more resistant. However, even the latter varieties have been observed to suffer severely under conditions favourable to blight infection.

III. THE OCCURRENCE OF *ALTERNARIA* BLIGHT IN PALESTINE

The *Alternaria* blight affecting the leaves of potatoes and the rot occurring on tubers appear in general to be due to A. *solani* (Ell. and Mart.) Sor. sensu Jones and Grant, while the possibility of other species of *Alternaria* being at least in part responsible for the disease cannot be excluded.

As stated above, *Alternaria* leaf blight is almost universally present on potato crops grown in this country, but ususally makes its appearance only in the second half of the growing period, i.e. 7-8 weeks after sowing. Earlier infection, about 5 weeks after sowing, is not infrequent on autumn sown crops in the Sharon plain. The infection of tubers by *Alternaria* was first observed in 1941 and is still rare (fig. 1).

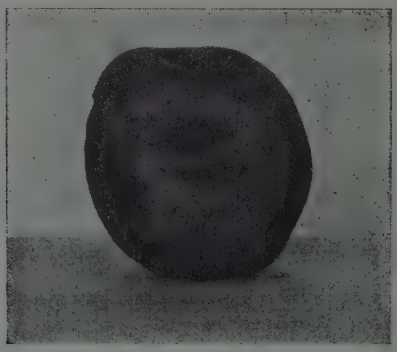


Fig. 1. Potato tuber showing symptoms of infection by *Alternaria*.

Varietal resistance to *Alternaria* leaf blight has not yet been studied in detail, but no very obvious differences in the incidence of this disease have so far been observed on the varieties most commonly grown, viz. Up-to-Date, Arran Banner, and Kerrs Pink.

IV. BLIGHT CONTROL TRIALS

The control of potato blights in Palestine during the past two decades was usually attempted by spraying with Bordeaux mixture at intervals of 2-3 weeks. These measures, however, often failed to give satisfactory control of *Phytophthora* blight. As regards *Alternaria* blight, farmers were doubtful not only of the efficacy of Bordeaux mixture in checking the disease, but also of the profitability of spraying against a disease which usually appears so late in the season. It was the purpose of the trials reported here

to initiate research into all problems relating to potato blight control in Palestine, to determine the profitability of spraying, and to examine the efficacy of the more important proprietary copper fungicides on the local market in comparison with Bordeaux mixture.

The execution of these trials has been possible only thanks to the co-operation of numerous persons throughout the country. We are obliged to Mr. Ch. Brisker, B. Sc., for his help in trial no. 1, and to the members of the collective settlements of Maabarot, Ain Shemer, Beth Alpha, Gan Shmuel, Mishmarot, and Giv'at Brenner, as well as to the Vegetable Growers' Association for facilities to carry out all the other trials.

A. Methods and Materials

The Up-to-Date variety was used in trials nos. 1-6 and no. 8, the Arran Pilot variety in trial no. 7. The sowing distances were 70-80 by 25-35 cm. The crop was lifted by hand. In trials nos. 6-8 the yield was graded according to the following grades: Grade A — tubers weighing more than 100 grammes; grade B — 60-100 grammes; grade C — below 60 grammes; grade D — culls. In these trials the market value of the crop, which depends on the size and grade composition of yield, was calculated by considering the value of a given weight of tubers of grades B, C, and D, to equal 70%, 50%, and 20%, respectively, of an equal weight of grade A tubers.—

The yield of all plots in one trial was lifted on the same day.

Significant differences were calculated by SAUNDERS' (10) adaptation of the analysis of variance, to a probability level of 1:20.

The incidence of *Phytophthora* and *Alternaria* blight was estimated on the following scale of categories and marks:

Category	*Phytophthora blight*	*Alternaria blight*	*marks*
A.	Free from blight symptoms		0.
B. Trace	a single lesion on one leaf	Up to 2 lesions on not more than $^1/_3$ the number of leaves	0.1
C. Light infection	Up to 2 lesions on the main stalk, or up to 5 lesions on leaf-stalks or leaves	Up to 2 lesions on every leaf or up to 4 lesions on not more than $^1/_3$ the number of leaves	0.5
D. Light-medium infection	Up to one third of the plant affected	Up to 4 lesions on every leaf	1.0
E. Medium-heavy infection	Up to two thirds of the plant affected	Up to 10 lesions on every leaf	2.0
F. Heavy infection	More than two third of the plant affected and begin to dry up	Up to one half of the plant dries up	4.0
G. Very heavy infection	Considerable or complete drying up	More than half the plant dries up	8.0

In the estimation of *Phytophthora* blight each plant was estimated separately, as the disease does not always affect all plants uniformly and a single estimate assigned to a whole plot appeared less accurate. In the case of *Alternaria* blight, on the other hand, a single estimate per plot seemed sufficient as all the plants are in general attacked to approximately the same extent. Blight estimates made on the treatment plots were expressed as percentages of the control estimate. If two estimations were made in the same trial, estimates were expressed as percentages of the control figure at the second estimation.

Methods of blight estimation have been discussed chiefly by English authors. BEAUMONT (1), after comparison of various possible ways of estimating incidence of *Phytophthora* blight, concludes that estimates basing on the number of lesions per plant will be the most reliable. In the estimation of considerable numbers of plants on many plots, which is necessary to obtain a correct average where infection is not uniform, this procedure is practicable only as long as the number of lesions per plant is still reasonably small. We therefore found it convenient to base only the lower categories of infection on the number of lesions, and the higher categories on the proportion of plant tissue affected. MARSH, MARTIN and MUNSON (4) have estimated *Phytophthora* blight on a scale based on the frequency of lesions and the degree of defoliation, and distinguish 6 categories of infection assigned marks in arithmetical progression (0, 2, 4, 6, 8, 10). In this way plots completely defoliated (10 marks) are assigned only 5 times as many marks as plots in which lesions are scarce (2 marks). In our view, a closer approximation to the relative amount of infection present in slightly, moderately, or severely infected plots is obtained where successive categories are assigned marks in geometrical progression, and the number of marks applied to very severely infected plots (8.0) exceeds that of slightly infected plots (0.5) sixteen times.

The materials tested were:

H o m e - m a d e B o r d e a u x m i x t u r e, prepared from 3 parts copper sulphate crystals and 2 parts of slaked lime dust (1 kg. copper sulphate and 660 grammes slaked lime for 100 litres of 1% Bordeaux mixture).

P e r e n o x, a proprietary spray based on cuprous oxide, containing not less than 50% metallic copper and 8% chlorine, with a slightly acid reaction; produced by Messrs. Imperial Chemical Industries, England.

C u p r o g r e e n C o n c e n t r a t e d, a proprietary spray based on copper oxychloride, containing aproximately 50% metallic copper, and neutral in reaction; a product of Belgium.

F l o r i d a n, a proprietary spray containing about 8% of metallic copper in ammoniacal solution, with an alkaline reaction; produced by Messrs. Tapazol, Rishon-le Tsion, Palestine.

P e r e l a n, a proprietary dust based on cuprous oxide and containing 17% metallic copper; produced by Messrs. Imperial Chemical Industries, England.

White oil (medium), stated to contain 80% oil, 40-49% distilling over at 636°F. with 92% unsulphonated residue; produced by Messrs. Shell Company of Palestine.

B. The Trials and their Results

1. Control of Alternaria blight.

Irrigation in all these trials was by overhead pipes. Trials nos. 1-3, carried out in the northern coastal plain, near Hadera, were mainly designed to compare the effectiveness of various copper sprays against *Alternaria* blight. In trial no. 1 sprays were applied by means of a knapsack sprayer at a rate of 140 litres per dunam, in trials nos. 2-3 by motor sprayers at a rate of 200 litres per dunam.

Trials nos. 4 and 5 were to test the efficacy of spray applications through the overhead irrigation pipes. The technique employed has been described elsewhere (7) and we need only repeat here that the rate of application through overhead pipes was very high, 400-600 litres per dunam, as compared with about 200 litres on the plots sprayed by motor sprayer in the usual way.

All further details of these trials appear in Table I, which also presents their results.

In all these trials *Phytophthora* blight failed to appear or was found only in traces, and only *Alternaria* blight developed more strongly.

The figures set out in table I clearly indicate that in all the trials infection of potatoes by *Alternaria* blight was greatly reduced by the copper sprays. In the first three trials Bordeaux mixture and Perenox equalled one another in their action, while Cuprogreen Concentrated was somewhat weaker. The addition of medium white oil to the Perenox spray did not affect the fungicidal action of the latter (trial no. 2). In trials nos. 4 and 5, Floridan, at 2% strength, was likewise shown to control the blight effectively and equalled the action of Bordeaux mixture 1%. In these trials overhead application of a copper spray, made at a very heavy rate, controlled *Alternaria* blight no less effectively than ordinary application by motor sprayer.

In the three trials in which yields were recorded, no appreciable yield increase resulted from the control of *Alternaria* blight. On the contrary, most of the copper treatments resulted in a slight (not significant) reduction of yield. The failure of spraying to increase yield would appear to be due to the fact that in trial no. 1 the disease appeared only 3-4 weeks before the crop was lifted, and in trials nos. 2 and 5, although the blight appeared somewhat earlier, its principal development did not take place until about 4 weeks before lifting. These results indicate that *Alternaria* blight does not notably depress the yield, if development of the disease comes late in the growing period of the host, when tuber production nears completion.

None of the copper sprays was observed to injure the foliage. Nevertheless, the slight reduction of yield in all trials indicates a

TABLE I (Trials nos. 1-5)

The effect of treatments on the incidence of Alternaria blight and on the size of the yield

Dates of sowing and lifting	Replicates: no. of plots	Replicates: size of each plot	Treatment	Incidence of Alternaria blight (control = 100) estimation no. 1	Incidence of Alternaria blight (control = 100) estimation no. 2	Mean size of yield in kg.: per plot	Mean size of yield in kg.: per dunam	Mean size of yield: %
			Trial no. 1, Pardess Hanna)*					
8th Jan.—			Control	51	100(7.6 marks)	105.8	1325	100
1st May	2	80m²	Bordeaux mixture 1%	8	54	85.5	1070	81
1941			Perenox ⅓%	9	45	98.3	1230	93
			*Trial no. 2, Maabarot**)*					
4th Sept.			Control	—	100(6.0 marks)	80.3	2670	100
1941 —			Bordeaux mixture 1.5%	6	17	70.3	2340	88
5th Jan.	4	30m²	Perenox ½%	—	17	71.3	2370	89
1942			Cuprogreen Conc. ½%	—	34	79.2	2640	99
			Perenox ½% + white oil 1%	—	17	65.5	2180	83
			do., every 2nd application	—	34	71.1	2370	89
significant difference:						9.6	1330	12.2
			*Trial no. 3, Ain Shemer***)*					
25th August —			Control	19	100(7.5 marks)		—	
December	6	30m²	Bordeaux mixture 1%	3	73		—	
1942			Perenox ⅓%	3	73		—	
			Cuprogreen Conc. ½%	6	100		—	
			Trial no. 4, Giv'at Brenner=)					
5th April —			Control	—	100(4.0 marks)		—	
27th July	1	200m²	Floridan 2% ordinary spraying	—	25		—	
1943			Floridan 2%, overhead application	—	25		—	
			Trial no. 5, Giv'at Brenner==)					
15th Sept. —			Control	—	100(7.0 marks)	30.3	2020	100
30th Dec.			Bordeaux mixture 1% ordinary spraying	—	14	29.1	1940	96
1943	4	15m²	Floridan 2% ordinary spraying	—	16	28.1	1870	93
			Floridan 2%, overhead application	—	25	32.6	2170	108
significant difference:						8.13	541	27

*) Treatments applied 8 times at 7—9 days' intervals between 18th February and 22nd April 1941. Blight appeared in early April. Estimations were made on 15th April and 1st May 1941.

**) Treatment applied 6 times at 6—9 days' intervals between 20th October and 28th November 1941. Blight appeared in early November, but spread only in December, and was estimated on 14th December 1941.

***) Rain continually interfered with the spraying operations. All sprays were applied only once on 24th October 1942. On 17th November rain curtailed the spraying after only the Bordeaux mixture and Cuprogreen Conc. plots, but not the Perenox plots, had been sprayed. The latter were thus only sprayed once. Blight appeared on 15th October and was estimated on 13th and 29th November 1942.

=) Treatments applied 4 times at weekly intervals, between 25th June and 16th July 1943. Blight appeared on 20th June and was estimated on 20th July 1943.

==) Treatments applied 4 times at weekly intervals, between 31st October and 23rd November 1943. Blight appeared in early November, spread slowly, and was estimated on 20th December 1943.

limited phytotoxic effect. In trial no. 2, the addition of medium white oil (1%) to Perenox caused considerable scorching and significantly reduced the yield below that of the control.

No clearcut results concerning the frequency with which sprays against *Alternaria* blight should be applied have been obtained in these trials. But the control of this disease does not generally appear to necessitate frequent applications. Thus, in trial no. 3, in rainy weather favourable for blight development, a single application of copper sprays largely checked infection for at least 2-3 weeks and its effect was still noticeable even after 5 weeks.

2. Control of Phytophthora and Alternaria blight.

TRIAL No. 6. This trial was carried out at Beth-Alpha, in the eastern part of the Valley of Esdraelon on a plot sown on 25th December 1942, irrigated by furrows and lifted on 4th May 1943. Each treatment comprised 5 replicate plots measuring 30 m². All further details relating to the trial are apparent from the following table:

Treatment	February		March							April			
	16th	19th	1st	8th	12th	17th	19th	29th	30th	2nd	10th	11th	19th
1. Control	first							f			s		
2. Bordeaux mixture 1%	record	+		+		dust		i	+		e	+	+
3. Perenox ⅓%	of	+		+				r	+		c	+	+
4. Cuprogreen	Phy-							s			o		
Concentrated ⅔%	toph-	+		+				t	+		n	+	+
5. Perenox ½%	thora	+		+					+		d	+	+
6. Perenox ⅓%, two	blight							e			e		
additional								s			s		
applications		+		+	+			t	+	+	t	+	+
								i			i		
7. Perenox ⅓% and								m			m		
Perelan dust after								a			a		
every rain		+	dust	+		dust	dust	t	+		t	+	+
								i			i		
8. Perenox ⅓% applied								o			o		
to leaves wet with								n			n		
dew		+		+					+			+	+

+ indicates that the plots were sprayed on the date in question.

On the date on which the sprays were first applied not more than one or two lesions of *Phytophthora* blight were present on about half the number of plants. Sprays were applied by motor sprayer at an average rate of 300 litres per dunam per application, while Perelan dust was applied at the rate of 5 kg. per dunam. As concerns treatment no. 8, the amount of dew present on the leaves at the first and second application was moderate, at the third and fourth application there was no dew, and at the fifth application dew was slight.

The results of this trial are summarized in table II.

TABLE II

Effect of treatments on incidence of Phytophthora blight and on size and grade composition of yield.

Treatment	Incidence of Phytophthora blight*) (3.4 marks = 100)	Mean size of yield in kg. per plot	Mean size of yield in kg. per dunam	Mean size of yield %	Grade composition of yield (mean %age weight of tubers) grade A	Grade composition of yield (mean %age weight of tubers) grade B	Market value of yield (control = 100%)
1) Control	100	9.92	330	100	1.32	22.34	100
2) Bordeaux mixture 1%	4	19.96	665	201	6.65	35.50	239
3) Perenox ⅓%	8	21.82	720	220	10.32	35.74	271
4) Cuprogreen Con. ⅔%	14	20.00	665	201	9.08	34.34	246
5) Perenox ½%	4	21.22	705	214	8.48	37.72	259
6) Perenox ⅓%, two additional applications	4	21.08	700	212	8.32	41.00	263
7) Perenox ⅓%, and Perelan dust after rains	6	18.46	615	186	7.40	39.22	228
8) Perenox ⅓%, applied to leaves wet with dew	7	19.98	665	201	8.34	46.36	254
significant difference:		3.435	114.4	34.6	5.33	7.38	46.9

The development of *Phytophthora* blight in the control plots was rapid. On 29th March, all the treatments were seen to have greatly reduced the incidence of disease. Among the various treatments only Cuprogreen Concentrated appeared to be a little weaker than the others. Perelan dust, applied 3 times up to the date of the first estimation, in addition to 2 applications of Perenox, did not reduce infection more than Perenox alone. There was no dif-

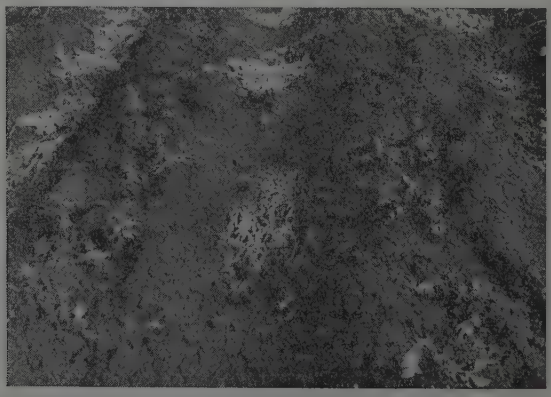


Fig. 2. Trial no. 6, Beth Alpha.
Untreated control plot. The plants have succumbed to *Phytophthora* blight.

*) 60 plants were estimated on each replicate plot.

ference between plots sprayed while the leaves were dry or still wet with dew.- On April 10th, the control plots were found to have dried up completely, while all the other plots were still well covered with leaves (cf. figs. 2 and 3). On 29th April, a few days before the crop was due to be lifted, half the foliage on the sprayed plots was still green, and only the plots sprayed with Cuprogreen Concentrated showed a higher proportion of drying up.



Fig. 3. Trial no. 6, Beth Alpha.
Plot sprayed with Perenox ⅓%. Growth is vigorous, infection by *Phytophthora* negligible.

As apparent from Table II, the general level of yield was low; all the treatments significantly increased the size of yield, the percentage weight of tubers in grades A and B, and thus the market value of the crop. The differences between Bordeaux mixture 1%, Perenox 1/3%, and Cuprogreen Concentrated 2/3% were not significant as far as size or grade composition is concerned. However, owing to slight advantages in size of yield as well as in the percentage of grade A tubers, the market value of yield from the Perenox plots was somewhat, though not significantly, higher than that from the Bordeaux mixture plots. The various variations of the Perenox treatment (higher concentration, two additional applications, application on to wet leaves) failed to differ appreciably from the treatment consisting of 5 applications of Perenox ⅓% on to dry leaves, and the effect of additional dustings with Perelan were even somewhat unfavourable.

TRIALS NOS. 7 and 8.

Both these trials were carried out in the northern coastal plain, near Hadera, on spring sown crops grown under overhead irrigation. Sprays were applied by motor sprayers at the rate of 150-200 litres per dunam.

TRIAL NO. 7. A plot of Arran Pilot potatoes, sown on 18th March 1943, was used in this trial. Each treatment was applied to 5 replicate plots measuring 20 m^2 each.

Phytophthora blight appeared during the last days of April. On 4th May, two days before spraying commenced, there were up to 3 blight lesions on each plant. Sprays were then applied to treatments nos. 2, 4, and 5, (cf. table III) on 6th, 10th, 16th and 23rd May, and to treatment no. 3 once less, on 6th, 16th and 23rd May. The blight spread at first rapidly, later more slowly. On 28th May infection on the control plots was moderately heavy, and the sprayed plots were hardly less infected. The formation of several typical infection centres, the incipient development of which certainly preceded the first application of sprays, rendered the accurate appraisal of treatment effects on *Phytophthora* blight somewhat difficult, and minor differences in the estimated incidence of disease under the various treatments cannot be regarded as reliable. The yield was lifted on 13th June 1943.

As apparent from table III, the level of yields was fairly high, and there was little difference between sprayed and unsprayed plots. The presence of the above-mentioned infection centres induced considerable fluctuations in the yields of plots under identical treatments, and differences between the various sprays were not significant.

TABLE III

Effect of treatments on incidence of Phytophthora blight and on size of yield

Treatment	Incidence of Phytophthora blight*) (1.7 marks = 100)	Mean size of yield in kg. per plot	Mean size of yield in kg. per dunam	Mean size of yield %
1) Control	100	72.6	2400	100
2) Perenox ½%, 4 applications	96	57.8	1925	81
3) Perenox ⅓%, 3 applications	79	70.1	2325	98
4) Cuprogreen Concentrated ¾%, 4 applications	96	66.8	2225	93
5) Floridan 2%, 4 applications	79	70.9	2350	99
significant difference:		19.25	641	26.9

TRIAL NO. 8. The plot of Up-to-Date potatoes was sown on 3rd April 1943. Each treatment comprised 6 replicate plots measuring 31 m². The sprays were first applied on 10th May, when the plots were still free from blight symptoms, and applications were repeated on 16th and 26th May, and on 3rd, 8th and 18th June 1943 in a total of 6 applications. The first symptoms of *Phytophthora* blight were recorded during the last days of May, and developed rapidly until the control plants were infected by about 10-15 lesions each. Thereafter strong development of *Alternaria* blight set in, and the combined effect of both blights caused the plants to dry up. When estimating the action of the sprays on disease development, we could therefore only estimate the percentage proportion of dried leaves and haulms on each plot, without separately appraising the effect of each disease.-

The results of this estimation (table IV) carried out on 1st July, 4 weeks before the crop was lifted, showed that Perenox and Bordeaux

*) 30 plants were estimated on each replicate plot.

mixture greatly reduced blight infection, while Cuprogreen Concentrated and Floridan did so to a smaller extent. The yield data set out in Table IV indicate that Perenox, Bordeaux mixture and Floridan significantly increased the size of yield as compared with the control and the plots sprayed with Cuprogreen Concentrated. All treatments significantly increased the percentage weight of tubers in grade A. Owing to their favourable effect on both size and grade composition of yield, the three spraying treatments mentioned first raised the market value of the crop by 20-30%; differences between these treatments were not significant.

This success of the sprays is all the more noteworthy, because spraying was discontinued much too early, about 4 weeks before the crop was due to be lifted. Further applications might well have given even larger yield increases.

TABLE IV

Effect of treatments on defoliation due to blight attack and on size, grade composition, and market value of yield

Treatment	Mean percentage of defoliation 4 weeks before lifting	Mean size of yield in kg. per plot	Mean size of yield in kg. per dunam	Mean size of yield %	Grade composition of yield (%age weight of tubers) grade B	Grade composition of yield (%age weight of tubers) grade A	Market value of yield (control = 100)
1) Control	92	64.7	1940	100	26.5	59.6	100
2) Bordeaux mixture 1%	27	75.6	2270	117	38.4	50.5	124
3) Perenox 1/3%	23	77.8	2330	122	41.6	47.9	129
4) Cuprogreen Conc. 2/3%	68	64.6	1940	100	36.7	51.7	105
5) Floridan 2%	57	73.5	2200	114	37.2	53.9	118
significant difference :		7.85	235	12.1	6.04		14.2

C. Discussion and Conclusions

1. Effect of spraying on disease development.

(a) Materials. The trials described in the foregoing sections have clearly shown the efficacy of the copper sprays tested in controlling both *Phytophthora* and *Alternaria* blight of potatoes. The efficacy of Bordeaux mixture has long been known, and that of the "fixed" copper sprays has recently been studied in many countries (2,4,5) and was generally found satisfactory. In our trials marked differences were apparent in the action of some of these sprays. Perenox, a spray based on cuprous oxide, when used at 1/3% (0.17% Cu.), equalled the action of Bordeaux mixture 1% (0.25% Cu) in controlling either of the two blight diseases.

In one trial Perenox was also tested at 1/2% strength, but the weaker concentration of 1/3% was found to be quite as effective in checking *Phytophthora* blight. The efficacy of Perenox against this blight has also been mentioned by British writers (5). Floridan, a spray based on an ammoniacal solution of copper, was only tested during one year; at 2% strength (0.16% Cu) this spray satisfactorily controlled both *Alternaria* and *Phytophthora* blight, but appeared to be a little weaker than Perenox 1/3% or Bordeaux mixture 1% in its effect on the latter disease. Cuprogreen Concentrated, a spray based on copper oxychloride, likewise controlled both blight diseases to a considerable extent, but was definitely less active than the other sprays, even when used at a concentration of 1/2-2/3% (0.25—0.34% Cu). As far as control of *Alternaria* blight is concerned, these results confirm the findings of Morgan and Hely (6) who, in trials carried out in Australia, found copper oxychloride spray to be weaker than Bordeaux mixture in checking this blight on tomatoes.

(b) timing and frequency of spraying. *Alternaria* blight was shown in trials nos. 3-5 to be adequately controlled by sprays first applied after appearance of symptoms on the leaves. The frequency and number of applications necessary for the control of this disease has not yet been directly established and this point will again be considered in the light of the yield results discussed below. Our results indicate, however, that very frequent spraying is not required in general; this may at least partly be attributed to the fact that *Alternaria* blight mostly appears during the second half of the growing period, when the haulms are no longer developing very rapidly. Applications at 8-10 days' intervals appear to afford adequate protection, where spraying cannot be dispensed with altogether (cf. below).

In the control of *Phytophthora* blight correct timing of the spraying operations is of the greatest importance. beaumont and large (2) recently concluded that in Britain timing was much more important than the kind of spray used; they stated that spraying was effective only if carried out when there were not more than 2 or 3 spots on each plant, while it failed if delayed for only two more days, i.e. until there were more than a dozen spots on each plant. This problem was not studied directly in our trials. We can only say that in trial no. 8, where the first application of sprays was made well in advance of blight appearance, and in trial no. 6 where spraying commenced when there were 1-2 blight lesions on every second plant, *Phytophthora* blight was controlled satisfactorily.

It is evident that the frequency with which sprays have to be applied for the control of this blight depends largely on the phase of growth of the host when attacked, on weather conditions, and on the degree of success with which early applications have been timed.

(c) OVERHEAD APPLICATION OF SPRAYS. The application of copper spray (Floridan 2%) through the overhead irrigation system effectively checked *Alternaria* blight, but the rate of application in these trials exceeded the normal by 2-3 times. These results and the advantages attaching to this method of spraying have been discussed elsewhere (7).

2. Effect of spraying on yield.

In the three trials for *Alternaria* blight control in which yields were recorded, the disease appeared late in the growing season, developed strongly only during the 4 weeks preceding harvest, and spraying did not increase the yield. Late appearance of this blight is thus seen to have no appreciable effect on yield; control measures are therefore advisable only where the disease appears more than one month before the crop is lifted, and where this is the case spraying may cease 3-4 weeks before lifting. This conclusion is in agreement with the finding of PETTY (8) in Louisiana (U.S.A.).

As regards *Phytophthora* blight, copper sprays were seen in trial no. 6 to protect the crop from almost total destruction and to ensure a yield which, under the conditions of that trial, was quite satisfactory. In trial no. 8, the combined attack of both blight diseases developed only during the second half of the growing season, but especially Bordeaux mixture and Perenox improved the size and grade composition of the yield to such an extent, that the market value of the crop rose by 25—30%. It would therefore appear that even late attacks of *Phytophthora* blight may be destructive enough to warrant spraying. In trial no.7, on the Arran Pilot variety, spraying did not increase the yield. We may conclude that in this variety slight infection by *Phytophthora* blight did not reduce yield appreciably.

The effect of the various sprays tested on the yield corresponded fairly closely with their efficacy in controlling *Phytophthora* blight. But Perenox 1/3%, although equalling Bordeaux mixture 1% in action, had a slightly better effect on the size of yield as well as on the percentage weight of tubers in grade A, and thus on the market value of the crop. Spraying with Cuprogreen Concentrated, at ⅔% strength, gave yields somewhat lower than those obtained with the other materials. This result is in agreement with the finding of BEAUMONT and LARGE (2), who also reported slightly lower yields to result from the use of two proprietary copper oxychloride sprays than from spraying with Bordeaux mixture.

V. SUMMARY

1. *Phytophthora* blight of potatoes (*Phytophthora infestans* (Mont.) de Bary) is of sporadic appearance in Palestine, being entirely absent in some years, while largely destroying the haulms, especially of winter and spring sown crops, in other years. Serious losses

from tuber infection have so far been experienced only on the autumn sown crop and may or may not be preceded by visible haulm infection. The regional and seasonal distribution of the disease in Palestine, and the relative resistance of the principal potato varieties are mentioned briefly.

2. Satisfactory control of *Phytophthora* blight was achieved in 1943 in 2 trials by spraying with Bordeaux mixture 1% (0.25% Cu) or with the proprietary cuprous oxide spray Perenox at 1/3% (0.17% Cu), and in 1 trial by spraying with the proprietary ammoniacal copper spray Floridan at 2% (0.16% Cu). The proprietary copper oxychloride spray Cuprogreen Concentrated (at 0.34% Cu) was definitely weaker in its action. — Adequate blight control increased the size of yield and improved the grade composition, thus raising the market value of the crop greatly.

3. *Alternaria* blight (*Alternaria solani* (Ell. and Mart.) Sor. sensu Jones and Grant) is very widespread on potato foliage in all parts of Palestine, but usually appears late in the growing season. Tuber infection has so far been rare.

4. The control of *Alternaria* blight was attempted in 5 trials carried out in 1941-1943 in all of which the disease appeared late. Bordeaux mixture 1% (0.25% Cu), Perenox ⅓% (0.17% Cu), and Floridan 2% (0.16% Cu) were about equally effective in decreasing the incidence of this blight, while Cuprogreen Concentrated 1/2% (0.25% Cu) was again weaker. Heavy applications of Floridan through the overhead irrigation system checked the blight. — Spraying failed to increase the yield and is concluded to be profitable only where *Alternaria* blight attacks the crop at an earlier stage of growth.

5. None of the copper sprays was observed to injure potato foliage, but slight yield reductions on sprayed plots in which diseases failed to appear indicated a certain, limited phytotoxic effect of these sprays. In one trial marked scorching followed the application of a spray composed of 1/2% Perenox and 1% white oil (medium).

REFERENCES

1. Beaumont, A. (1933). Symposium and discussion on the measurement of disease intensity. I. Potato blight.
— Trans. Brit. Myc. Soc. 18:174-176.

2. Beaumont, A., & Large, E. C. (1942). Potato spraying in the south-west. Lessons from 1941.
— J. Minist. Agric. 48:235-240.

3. Littauer, F. (1937). Phytophthora blight of potatoes.
— Agr. Res. Stat. of the Jewish Agency, Ext. Div., Leafl. 43, 8 pp. (Hebrew).

4. Marsh, R. W., Martin, H., & Munson, R. G. (1937). Studies upon the copper fungicides. III. The distribution of fungicidal properties among certain copper compounds.
— Ann. Appl. Biol. 24:853-866.

5. Marsh, R. W., & Martin, H. (1942). Simplified methods of potato blight control. Progress report III.
— Rept. Long Ashton Agr. Hort. Res. Sta. for 1941, pp. 79-82.

6. Morgan, W. L., & Hely, P. C. (1941). Combined sprays for late tomatoes.
— J. Aust. Inst. Agr. Sci. 7:158-161.

7. Palti, J., & Moeller, S. (1944). Overhead application of fungicidal sprays (preliminary experiments).
— Pal. Journ. Bot., Rehovot Ser., 4 (2): 184-192.

8. Petty, M. A. (1938). Potato spraying experiments in Louisiana during 1936-1937.
— Amer. Potato Journ. 15:189-191.

9. Pittman, H. A. (1929). Early blight or leaf spot and the Macrosporium storage disease of potatoes.
— Journ. Dept. of Agr. West Australia 6 (2nd. Ser.): 544-552.

10. Saunders, A. R. (1939). Statistical methods with special reference to field experiments.
— S. Afr. Dept. Agr., Sci. Bull. 200, 111 pp.

RUST AND CHOCOLATE SPOT OF BROAD BEANS IN PALESTINE*)

By I. REICHERT and J. PALTI

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot.

	Page
Introduction	201
The distribution of rust and chocolate spot on broad beans	202
a) In Palestine	202
b) In some foreign countries	205
c) Temperature relations	206
Control trials under market-garden conditions	207
Conclusions	210
Summary	211
References	212

INTRODUCTION

Broad beans (*Vicia faba*) are suited to fulfil diverse and important functions in the agriculture of Palestine. As a fodder crop, they supply valuable green matter and seeds and are widely used for silage purposes. As a market garden crop, their pods enjoy a steady demand. Moreover, broad beans are particularly useful on intensively cultivated areas owing to their market resistance to root diseases, such as *Sclerotinia sclerotiorum* (Lib.) Mass. and *Sclerotium bataticola* Taub. However, in contrast to their resistance to these troubles, broad beans in Palestine are subject to the attack of numerous destructive diseases of the leaves, stalks and pods. The most important of these are rust [*Uromyces fabae* (Pers.) DeBy.] and chocolate spot (*Botrytis fabae* Sard.), while leaf spots caused by a species of *Macrosporium* and *Ascochyta* blight (*A. fabae* Speg.) are less common. The combined effect of these diseases is so devastating, that numerous growers despair of raising a paying crop of broad beans and prefer to substitute other leguminous crops.

In order to determine whether or not this decision is justified, investigations were begun in 1930 to survey the distribution in Palestine, in various seasons and districts, of the two principal diseases, rust and chocolate spot. Fungicidal trials for the control of these diseases were commenced in 1940 under market garden conditions. The purpose of this work was to establish where and when it would be possible to grow broad beans in Palestine with the least risk of diseases, and whether occasional spray applications—

*) Under the auspices of the Meteorological Research Council, Jerusalem.

timed in accordance with the ecology of disease development — would be a paying proposition.

THE DISTRIBUTION OF RUST AND CHOCOLATE SPOT ON BROAD BEANS

(*a*) *In Palestine*

Broad beans, in Palestine, are usually sown between October and December and their growing period extends up to April-May. Our surveys showed that the development of r u s t begins usually in February and continues until April or May. With the exception of the inner valleys, rust symptoms are seldom seen as early as January. Rust is common in all agricultural districts, including the coastal plain, Samaria, the Jerusalem district, the Upper and Lower Galilee, and the inner valleys (Jordan Valley, Beisan Valley, Valley of Esdraelon).

C h o c o l a t e s p o t s , on the other hand, frequently appear in January and appear to cease their development in April. This disease is also common in all the above districts, with the exception of the vicinity of Jerusalem where it has not yet been recorded.

In order to elucidate the causes underlying the above differences in the occurrence of the two diseases at certain seasons, field records were compared with macroclimatical data of some of the districts covered by the survey. These data together with excerpts of the field records appear in table no. I. It should be added that all observations were made on plots irrigated by furrows or by flooding, and only at Pardess Hana were the plots irrigated by overhead installation. In some cases no irrigation was applied during the growing period as rain fell in sufficient amounts.

Of the data presented in the table, those concerning Mikve Israel are of special interest. In the three years covered by our survey in this locality, chocolate spots were always first recorded between the 9th and 25th January. Rust, however, appeared on widely differing dates. In 1940/41 rust was first recorded as early as 25th January, in 1942/43 on 25th February, and in 1941/42 as late as 19th March. In these three years mean relative humidity in the months of January did not differ greatly and was usually between 70 and 80%. Both the number of rainy days and the amount of rainfall were much higher in January 1943 than in that month in 1941 and 1942. The greatest difference in the data for the three years is apparent with regard to temperature. In 1940/41, when rust appeared early, the mean daily temperature in December and January was 15.6-16.3°C. In 1941/42, when rust appeared so late, the corresponding figures were only 9.8-10.5°C, while in 1942/43 rust appeared in February after December-January temperatures of 13.3-12.8°C.

TABLE I.

The meteorological conditions accompanying the occurrence of rust and chocolate spot on broad beans in Palestine.

Locality of disease record	Date of sowing	Meteorological Data*) month and year	rainfall: no. of rainy days	rainfall: amount in mm.	Daily mean of: rel. humidity %	Daily mean of: temp. in °C	Excerpts from field records on disease occurrence
Mikve Israel (Central coastal plain)	25.11. 1940	Dec. '40	7	194	76	15.6	*Chocolate spot* first recorded 9.1.41, *rust*, 23.1.41. Until 25.2.41 choc. spot progressed little, rust moderately. On 4.4.41 all plants dried up by rust.
		Jan. '41	10	52	73	16.3	
		Febr. '41	5	26	74	17.0	
		March '41	8	167	76	17.3	
	9.12. 1941	Dec. '41	19	191	80	10.5	*Chocolate spot* first recorded 25.1.42, developed very slowly. *Rust* first recorded 19.3.42, strong attack in April.
		Jan. '42	9	91	71	9.8	
		Febr. '42	5	44	70	10.6	
		March '42	7	42	74	12.8	
		April '42	1	1	71	18.6	
	26.11. 1942	Dec. '42	6	20	75	13.3	*Chocolate spot* first recorded 14.1.43, developed little in March, moderately in March-April. *Rust* first recorded 25.2.43, moderate development in April.
		Jan. '43	19	210	72	12.8	
		Febr. '43	11	93	70	12.5	
		March '43	17	95	66	14.2	
		April '43	7	46	70	16.4	
Ashdot Ya'aqov (Upper Jordan Valley)	? Dec. 1939	Jan. '40	?	137	78	14.4	*Chocolate spot* and *rust* recorded 26.1.40.
	Nov. 1941	Dec. '41	12	154	80	13.5	*Chocolate spot* infection slight, *rust* infection moderate to severe on 17.3.42
		Jan. '42	4	34	68	12.4	
		Febr. '42	6	49	74	13.4	
		March '42	8	63	76	15.8	
Hanita (Western Galilee)	Dec. 1942	Jan. '43	18	400	75	10.1	Only *chocolate spot*, no *rust*, recorded on 14.3.43
		Febr. '43	14	107	74	10.1	
		March '43	18	136	71	10.9	
Ayelet Hashahar (Upper Galilee, Huleh Basin)	24.12. 1942	Jan. '43	14	194	83	9.6	Strong attack of *chocolate spot*, no *rust*, recorded on 29.4.43.
		Febr. '43	10	34	79	8.8	
		March '43	15	135	77	9.0	
		April '43	15?	70	68	14.3	
Sarid (Valley of Esdraelon)	7.12. 1939	Jan. '40	?	148	83	12.7	Only *chocolate spot*, no *rust*, recorded on 7.3.40.
		Febr. '40	?	61	84	11.1	

*) The rainfall data are quoted from the Annual Rainfall Summaries published by the Meteorological Service of the Government of Palestine. The data for relative humidity and temperature are quoted from "Meteorological Data for Palestine" Vol. III—IV by Dr. D. Ashbel, of the Hebrew University, Jerusalem. The latter data represent means of 24 hourly records per day, as registered by self-recording instruments.

Comparing the records for Mikve Israel with those made in other parts of the country, we observe some interesting differences. In March 1942, almost on the same day on which the first record of rust was made at Mikve Israel, infection by this disease had reached moderately heavy proportions at Ashdot Ya'aqov, in the Jordan Valley. This may confidently be attributed to the fact that in this locality the mean temperature for December-February was always about 3 degrees higher (12.4-13.5°C) than at Mikve Israel. — In 1942/43 observations parallel to those at Mikve Israel were carried out at Hanita, in the mountains of the Western Galilee, and at Ayelet Hashahar, south of the Huleh Basin in the Upper Galilee. In all three localities mean relative humidity and the number of rainy days in January-March was fairly uniform, though the amount of January rainfall in Hanita was much higher. But mean daily temperatures differed markedly in these months, being 10.1-10.9°C at Hanita and 8.8-9.6°C at Ayelet Hashahar as compared with 12.5-13.3°C at Mikve Israel. In the former two localities only chocolate spots, but no rust, were recorded, while both diseases were present at Mikve Israel. — Two further comparable records were made in 1939/40 at Ashdot Ya'aqov and Sarid (Valley of Esdraelon). In the former locality both rust and chocolate spot were recorded in January, while in the latter only chocolate spot was found to be present in early March. Here again atmospheric humidity and rainfall in January were very similar in both places. But mean daily temperature in January 1940 was 14.4°C at Ashdot Ya'aqov, as compared with 11.1°C (and 12.7°C in February) at Sarid.

If these data are to serve as the basis for conclusions concerning the meteorological conditions favouring the outbreak of rust and chocolate spot in Palestine, such conclusions must always be subject to the following considerations: (a) The effect of the age of the host plant on its susceptibility to the diseases has not been studied, but we are inclined to believe that rust infection, under equal conditions, is more readily established on older than on younger bean plants. (b) For the purpose in view, the value of monthly means of meteorological data is necessarily limited, especially in the spring months when conditions in the first half of the month may differ widely from those in the second half.

With due allowance for these limitations, the data in table I may be interpreted as follows:

Chocolate spot. This disease was simultaneously recorded in widely differing parts of the country (coastal plain, Jordan Valley, Upper Galilee). In fields sown in November-December, chocolate spots were usually first recorded in January. Even marked differences in the mean temperatures recorded in December and January, e.g. 10°C recorded at Mikve Israel in 1941/42 as compared with 16°C in 1940/41, did not materially affect the date of disease appearance. Our

data do not permit any conclusions regarding the effect of various levels of relative humidity and rainfall on the development of chocolate spots.

Rust. Unlike chocolate spots, the appearance of rust symptoms on comparable crops of beans in various districts, or in consecutive years in the same district, was often recorded on dates differing by as much as two months. These differences seemed to be related to the levels of temperature. At daily means of 10°C or below, rust was never found to occur. In or after months with daily means of 12.5°C the disease sometimes appeared (Mikve Israel, February 1941 and March 1942), but failed in other cases to appear (Sarid, January-February 1940), although relative humidity was high. This absence of regularity is, of course, to be expected near the threshold temperature of rust appearance, as we are dealing with the means of entire months (cf. above). At temperatures of 14°C and above, rust appeared at relative humidities of 73-78% in localities where the preceding month was also fairly warm (Mikve Israel, January 1941, and Ashdot Ya'aqov, January 1940), but not at a relative humidity of 68% where the preceding months were colder (Ayelet Hashahar, April 1943). As regards the further development of rust after the first outbreak, mean temperatures of about 17°C at a relative humidity approximating 75% were seen at Mikve Israel in 1941 to enable the rust to cause complete drying up of the bean plants within a period of 8-10 weeks after appearance of the first pustules (cf. figure 1). The amount of rainfall and number of rainy days per month did not decisively affect the appearance of rust, and at low temperatures the disease failed to appear even in very rainy months (e.g. after 18 rainy days and 400 mm. rainfall at Hanita in January 1943). But it is possible that at higher temperatures high rainfall assists the rapid spread of rust.

(b) *In Some Foreign Countries*

The occurrence of rust and chocolate spots on broad beans has been reported from many countries in different parts of the globe. Many of these records are contained in check-lists of fungi collected in various territories, and are not accompanied by detailed information regarding the season, exact locality, and climatic conditions where the diseases were found. Only a part of these check-lists was at our disposal. We have attempted to glean from these and from other publications some records pertinent to this study, and shall now discuss such records in relation to meteorological data of the localities in question, as collected from "World Weather Records" (13), and in relation to the conclusions outlined above with regard to the conditions favouring the diseases in Palestine.

New South Wales. Noble et al. (9) list both rust and chocolate spot (which was then still attributed to aphis infestation) as diseases of general occurrence in New South Wales. This country, according to the means recorded at Sydney from 1859 to 1924, enjoys

a steady rainfall of 73-145 mm. in each month of the year, with mean monthly temperatures ranging from 11.5°C in July to 22°C in January. MAGEE (7), in a paper on the etiology of chocolate spot, records collection of the disease on 23rd July 1940. The temperature and rainfall data for Sydney were in June 1930 13.6°C and 307 mm., and in July 1930 13.3°C and 102 mm.,, respectively. - It will thus be seen that the conditions under which rust and chocolate spot appear in New South Wales may well accord with those found in Palestine.

England. OGILVIE (10) states that "chocolate spots can be found almost every year from December onwards, but the most serious epidemics take place in spring or early summer, from April to July ; rust is found every year, but usually appears too late to bring about appreciable losses". According to Greenwich records (1841-1920), mean monthly temperatures there range from 3.8 to5.5°C in December-March, then rise to 8.3°C in April, 11.8°C in May, and 15.1.-17.0°C in June-July. We would not therefore expect rust to become serious before June, while chocolate spots should not normally be prevalent before April. This is in exact agreement with OGILVIE's statement.

U.S.A. In his check list of diseases of economic plants in the United States, ANDERSON (1) mentions *Uromyces fabae* as occurring on broad beans in the states of Louisiana and Alabama. The records for Mobile, Alabama, for 1873-1923 show that a mean rainfall of 89-185 mm. occurs there in every month of the year, and that mean monthly temperatures range from 10.6°C in January to 26.9°C in July. These temperatures are fairly similar to those recorded in the coastal plain of Palestine where rust is so abundant in spring.

Southern Rhodesia. HOPKINS (6) lists *Uromyces fabae* among the diseases affecting broad beans in Southern Rhodesia, but gives no indications of the localities or season in which the disease occurs. As apparent from the weather records for Salisbury (1896-1923), mean monthly temperatures during the months with any rainfall worth considering amount to 18.7-21.5°C. These temperatures are somewhat above those at which rapid development of the disease was noted in Palestine.

(c) *Temperature Relations*

In most publications on chocolate spots of broad beans, mention is made of the favourable effect of humid conditions on the development of this disease. The temperature relations of *Botrytis fabae* have also been studied by various authors. EL-HELALY (2) determined the optimum for the growth of the fungus to be 20°C, and for germination of spores to be 21°C. WILSON (12) found the optimum, maximum and minimum for infection to be at 20°C, 30°C, and 1°C, respectively. MOORE (8) considers temperatures of 16-20°C to be most favourable for development of the disease. In our observations,

chocolate spots were sometimes found to develop strongly in months with daily mean temperatures of about 10°C, i.e. considerably below the optimum indicated by the above authors. Ogilvie's (10) mention of the outbreak of serious epidemics of the disease in England beginning from April (when the daily mean at Greenwich is only 8.3°C) confirms the view that *Botrytis fabae* ranks among the fungi capable of causing severe damage at relatively low temperatures.

The effect of environmental conditions on *Uromyces fabae* has not been extensively studied. As far as we are aware, only Hiratsuka (5) has investigated the effect of various temperatures on this rust. He found the optimum for uredospore germination to lie between 16 and 22.5°C; the maximum development of sori took place at 14-24°C. These data agree with our findings that rust never developed in months with daily means around 10°C, began to develop at about 12.5-14°C, and assumed epidemic proportions at 17°C or above. As this is also in agreement with the seasonal spread of the disease in England (10), and nothing incompatible with this view was found in the data pertaining to the occurrence of the disease in New South Wales, Alabama, and Southern Rhodesia, we may conclude that *Uromyces fabae* is restricted in its development to moderately warm or warm conditions.

CONTROL TRIALS UNDER MARKET-GARDEN CONDITIONS*)

Materials and methods. All trials were carried out on the local "Damascus" variety in plots sown in rows 1 metre apart, with 15-20 cm. between the plants in the row.

Sprays were applied by knapsack-machines working at 4-8 atmospheres' pressure. The following proprietary materials were tested:

Perenox — a spray based on cuprous oxide, containing at least 50% Cu and 8% chlorine, with a slightly acid reaction. Produced by Messrs. Imperial Chemical Industries Ltd., England.

Sulfinette — a lime-sulphur spray with 33° Baumé; produced by Messrs. Cooper, McDougall & Robertson, England.

Cita Californian Spray — a lime-sulphur spray with 30-32° Baumé; produced by Messrs. Chemical Industries Tel Aviv.

The incidence of rust, chocolate spot, and *Macrosporium* blight was estimated by assigning each plot one out of 8 categories of infection which were given 0.1, 0.5, 1.0, 2.0, 4.0 and 8.0 marks, respectively. Each disease was estimated separately. The category corresponding to 1.0 mark denoted infection of up to half the number of leaves on not more than half their surface. 4.0 marks were given when most leaves were infected up to half their surface, but some leaves began to dry up, while 8.0 marks denoted far-reaching desiccation of the leaves.

*) The authors are obliged to Messrs. B. Capuler, F. Genazzani and Ch. Brisker for the help rendered in the execution of these trials.

Results. Details of the treatments tested and the dates of their applications appear in table No. II, together with the results of the estimations of disease incidence and with the yield records.

TABLE II.

The effect of spraying on the incidence of broad bean diseases and on the yield.

sowing	Treatment	Dates of application	Total no. of applications	Chocolate spot: Date of first record	Chocolate spot: marks	Rust: Date of first record	Rust: marks	Macrosporium: Date of first record	Macrosporium: marks	Yield of green pods: kg. per drum	Yield of green pods: %
	Trial no. 1, Pardess Hanna)*										
.12.	Control	—	—	20.1. 1941	1.8	?	4.0	25.1. 1941	4.0		
40	Sulfinette 1.66%	26.1.—27.3.41, at 8 days' intervals	8		1.8		1.0		0.8		
	Perenox 0.33%				0.1		0.7		0.5		
	Perenox 0.33%	2.2., 13.2., 28.2., 17.3.41	4		0.1		2.0		0.7		
	*Trial no. 2, Mikveh Israel**)*										
.11.	Control	—	—	8.1. 1941	3.0	23.1. 1941	8.0	23.1. 1941	6.0	960	100
40	Sulfinette 1.66%	15.1.—4.4.41, at 8 days' intervals	8		2.0		6.0		6.0	1200	125
	Perenox 0.33%				1.0		2.0		2.0	1520	158
	significant difference (p=0.05):									188	19.6
	*Trial no. 3, Mikveh Israel***)*										
.12.	Control	—	—	25.1. 1942	1.0	19.3. 1942	6.0	?	1.0	1132	100
41	Cita Californian Spray 1.5%	27.1.—21.4.42, at 10 days' intervals	9		0.1		2.0		0.5	1000	89
	Perenox 0.33%				0.1		0.1		0.1	1040	93
	Perenox 0.33%	27.1.—16.4.42, at 15 days' intervals	6		0.1		0.2		0.4	1040	93
	Perenox 0.33%	27.1.—21.4.42, at 20 days' intervals	5		0.5		0.4		0.5	1040	93
	significant difference (p=0.05):									356	31.8
	Trial no. 4, Mikveh Israel=)										
.11.	Control	—	—	14.1. 1943	2.8	25.2. 1943	4.5	14.1. 1943		375	100
942	Perenox 0.33%	1.3., 14.3., 26.3., 8.4., 15.4.	5		0.9		0.8			485	129
	Perenox 0.33%	1.3., 26.3., 15.4.	3		2.5		2.3			500	134
	significant difference (p=0.05):									205	54.7

*) Each treatment applied to a single plot of 25 sq. m. Development of plants was weak and yield therefore not recorded. Estimation of diseases on 8.4.41.

**) 3 replicates of 36 sq. m. to each treatment. Diseases estimated on 4.4.41. Owing to very strong rust development, incidence of the other diseases could not be determined with accuracy.

***) 3 replicates of 36 sq. m. to each treatment. The final estimation of rust and Macrosporium blight was made on 1.5.42. The rust then obliterated chocolate spots, and results of an earlier estimation (25.3.42) are presented in respect of the latter disease.

=) 4 replicates of 24 sq. m. to each treatment. Diseases estimated on 22.4.43. The incidence of Macrosporium blight was too slight to be estimated.

(1) Materials. The table clearly shows the efficacy of Perenox, at 0.33% strength, in controlling rust and chocolate spot in all 4 trials, and in controlling *Macrosporium* blight in trials Nos. 1 and 2. Spraying with lime-sulphur sprays (whether Sulfinette or Cita Californian Spray) at 1.5% strength was always less effective in checking the former two diseases; in trials Nos. 2 and 3, where the attack of rust was severe, the action of these sprays fell quite definitely short of that of the copper spray Perenox. The results are not so clear where the effect of lime-sulphur sprays on *Macrosporium* blight is concerned: in trial No. 1 their action on this disease was satisfactory, but this was not confirmed in trial No. 2. These conflicting results may possibly be explained by the fact that *Macrosporium* may in part develop saprophytically on tissue killed by rust. In trial No. 2 rust infection on the plots sprayed with lime-sulphur spray was severe, and thus Macrosporium was more prevalent than in trial No. 1 where both diseases developed weakly on these plots.

Fig. 1 indicates the action of Perenox in protecting broad beans from leaf diseases, as observed in trial no. 2 at Mikveh Israel in 1940/41.



Fig. 1. Trial no. 2, Mikveh Israel, 1940/41.
On the right: Untreated Control row; the leaves have dried up, mainly owing to rust attack, and the stalks are prominent.
On the left: Row sprayed with Perenox ⅓%; the plants are still fully covered with leaves.

Our above results concerning the action of sprays on rust and chocolate spot are in agreement with those reported from other countries. El-Helaly (4) found in Egypt that copper sprays give good control of the two diseases and are preferable to sulphur treatments.

reported 1% Bordeaux mixture to control chocolate spot more effectively than lime-sulphur sprays, and in China(11) 0.6% Bordeaux mixture has proved effective against rust.

(2) Timing and Frequency of Spray Applications. The results of trial No. 4 indicate that rust may be adequately controlled by applications of Perenox beginning a few days after the first symptoms have appeared. As seen in all our trials, this also holds good for the control of chocolate spot. El-Helaly(4) likewise recommends, under Egyptian conditions, to begin spraying after rust or chocolate spot have first been recorded.

The frequency with which sprays should be applied can obviously only be discussed in relation to the severity of disease development. Applications of Perenox at 7-10 days' intervals succeeded in checking both rust and chocolate spot in all trials, even where conditions were most favourable to rust outbreaks (trial No. 2). Weekly applications against this disease have also been advocated in China(11). In trial No. 3, the incidence of disease was too slight to permit comparisons of the effect of various frequencies of application. In trial No. 4, 5 applications at 12-14 days' intervals resulted in a final incidence of rust and chocolate spot considerably lower than that obtained with 3 applications at intervals of 20 days, but there was no difference in the yield picked under the two treatments. El-Helaly (3) has found up to 4 weeks to be a suitable interval for the application of sprays for rust and chocolate spot control in Egypt.

(3) Yield. In all the three trials in which the yield of green pods was recorded, the incidence of rust by far surpassed that of other diseases. The trials differed chiefly in the date of rust appearances In trial No. 2 the disease appeared early, about 2 months after sowing, while in trial No. 4, 3 months elapsed between sowing and rust appearance, and in trial No. 3 the disease was first recorded as much as 3½ months after sowing, i.e. 6 weeks before picking of pods was terminated. The yield increases obtained by spraying with Perenox corresponded to the date of rust appearance. Where the attack was early, the weight of pods was significantlyt increased by 58% (546 kg. per dunum) as compared with the control plots; where rust appeared somewhat later (trial No. 4) the increase of yield was smaller and not significant; and where the rust appeared very late (trial No. 3) no yield increase resulted from spraying although the disease developed very rapidly to reach a final rating of 6.0 marks.

CONCLUSIONS

The above observations and trials permit certain conclusions concerning ways and means of avoiding or reducing damage by rust or chocolate spot to broad beans grown as forage or vegetable crops.

a) *Irrigated crops.*

If the crop is intended for green fodder supply, it should be sown early, from early October until mid-November. These sowings

This author recommends spraying with Bordeaux mixture at concentrations ranging from 0.5% to 2.0%. In England, Wilson(12) can be cut between mid-December and mid-January and will not therefore suffer from rust, which develops later. The crop may be affected by chocolate spot, especially in the inner valleys of Palestine, but the loss caused by this disease until mid-January is usually limited.

Crops sown for green pods should also be sown early, so that picking may begin in early February. These crops have to be sprayed with Perenox 1/3% after the first appearance of rust symptoms. Spray applications should be repeated 2-3 times at fortnightly intervals, ending in late March. If rust has not appeared by mid-March, spraying is no longer necessary.*)

b) *Non-irrigated Crops.*

Broad beans intended for silage or grown for seeds are not usually irrigated; their sowing date cannot therefore be varied at will and depends on the onset of rains, which is usually in November. These crops are liable to suffer from chocolate spot in all parts of the country, and from rust especially in those parts where temperatures in January and February are relatively high. The comparatively low economic value of these crops will not cover the expenses of spraying, in any case not for the time being, while the amount of labour involved is still high. We therefore have to conclude that in Palestine sowing of broad beans as a non-irrigated crop for the above purposes is attended by many hazards and will be a paying proposition only if varieties resistant to rust and chocolate spot can be grown.

SUMMARY

Investigations were carried out from 1939 to 1943 to determine ways and means of growing broad beans in Palestine without excessive risk of losses from attack by rust (*Uromyces fabae*) and chocolate spot (*Botrytis fabae*).

A study of field records of these two diseases in various parts of the country in relation to monthly macroclimatical records has led to the conclusion that in Palestine the appearance of chocolate spot is not markedly affected by the mean daily temperature, and under comparable conditions the disease appears at means of 10°C and 16°C on very similar dates. Rust, on the other hand, is much dependent on the level of temperature, failing to appear in months with daily means of 10°C or less, occurring occasionally at means of about 12.5°C, but appearing regularly only at 14°C or above. Observations concerning the effect of various levels of relative humidity and rainfall were less conclusive.

*) At the present level of prices (1 day labour = LP.1.---, 1 kg. Perenox = LP. 0.250) each application will cost about LP. 0.450 per dunum. This is amply covered by the increased yield of pods, where rust is severe. The labour expenses involved in spraying may be expected to decrease shortly with the perfection of techniques for the application of sprays through overhead irrigation systems.

The above conclusions have been found in fair agreement with the climatical conditions (as gleaned from "World Weather Records") obtaining in other countries in which rust and chocolate spot occur on broad beans, and with the results of various studies of the temperature relationships of the fungi concerned.

Four spraying trials have shown rust and chocolate spot to be controlled by spraying with the proprietary cuprous oxide spray Perenox, at 1/3% strength (0.17% Cu), while lime-sulphur sprays were much less effective. Control was adequate where applications of Perenox began just after disease appearance and were repeated at intervals of 10-14 days. Spraying increased the yield of green pods significantly where the attack of rust was early and severe.

Basing on the results of these observations and trials, practical recommendations are made for reducing the disease hazard in irrigated crops of broad beans (grown for green fodder or green pods) by early sowing and timely spraying. As regards non-irrigated crops (for silage and seeds), which can only be sown after the first rain, no practical control measures can be recommended and their cultivation entails a considerable risk.

REFERENCES.

1. Anderson, P. J., et al. (1926). Check list of the diseases of economic plants in the United States. — U.S.D.A., *Dept. Bull.* 1366.
2. El-Helaly, A. F. (1938) A chocolate spot disease of beans (Vicia faba). Part I. — *Bull. Min. Agric. Egypt No.* 191, 8 pp.
3. El-Helaly, A. F. (1939). Preliminary studies on the control of bean rust. — *Bull. Min. Agric. Egypt* no. 201, 19 pp.
4. El-Helaly, A. F. (1939). Further studies on the control of bean rust with some reference to the prevention of chocolate spot of beans. — *Bull. Min. Agric. Egypt* no. 236, 23 pp.
5. Hiratsuka, N. (1934). Physiological studies on Uromyces fabae f. sp. Viciae-Fabae. — *Bot. Mag., Tokyo*, 48, 569, pp. 309-325. Abstr. in R. A.M. XIII, p. 670.
6. Hopkins, J. C. F. (1939). A descriptive list of plant diseases in Southern Rhodesia. — *Dept. Agric. S. Rhodesia, Memoir ns.* 2, 51 pp.
7. Magee, C. J. (1933). Etiology of the chocolate spot disease of broad beans. — *Dept. Agric. N. S. Wales, Sci. Bull.* 43, 7 pp.
8. Moore, W. C. (1940). From discussion on plant diseases and the weather. — *Trans. Brit. Myc. Soc.* 24: 264.
9. Noble, R. J. et al. (1935). Plant diseases recorded in New South Wales. — *Dept. Agric. N. S. W., Sci. Bull.* 46, 47, pp.
10. Ogilvie, L. O. (1942). Diseases of Vegetables. — *Min. Agric. & Fisheries, Great Britain, Bull.* 123, 69 pp.
11. Tsui, P. T., & Lin, C. (1937). Experiments on the effect of spraying fungicides to control broad bean rust. (Chinese). *Abstr. in R.A.M.*, 17:154.
12. Wilson, A. R. (1937). The chocolate spot disease of beans (Vicia faba L.) caused by Botrytis cinerea Pers. — *Ann. Appl. Biol.* 24(2): 258-288.
13. World Weather Records. (1927). *Smithsonian Misc. Coll. Vol.* 79.

FIELD TRIALS FOR THE CONTROL OF DOWNY AND POWDERY MILDEW OF CUCUMBERS

II. THE COMPARATIVE EFFICACY OF COPPER AND SULPHUR FUNGICIDES

By I. REICHERT, J. PALTI and S. MOELLER,
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

Page

I. Introduction 214

II. Materials and methods 216

III. The trials and their results
A. The comparative effect of copper and sulphur materials 216
(1) On plots with furrow irrigation 216
(2) On plots under overhead irrigation 221
B. The frequency of fungicidal applications 223

IV. Discussion
A. The effect of sulphur on downy mildews 224
B. The action of the copper treatments tested 225
C. The control of aphids by sulphur dust 225
D. Phytotoxic effects 226
E. Irrigation and downy mildew development 226

V. The profitability of treatments 227

VI. Summary 227
References 228

I. INTRODUCTION

The trials described in this paper were carried out in 1942-1944 in continuation of the work of which first results were published some time ago (7). The earlier work was primarily concerned with the control of the downy mildew disease of cucumbers (*Pseudoperonospira cubensis* B. et C.) by the use of copper fungicides, which are accepted as the standard means of checking this disease in all the countries of its occurrence. It was found that under the conditions prevailing in Palestine downy mildew may well be checked by copper sprays, provided these are applied with sufficient frequency. Most of these sprays, however, were apt slightly to injure the foliage and consequently increased

the yield only where disease development was early, rapid and destructive. Where appearance of the disease was delayed or the rate of its development slow, copper sprays not infrequently reduced the size of yields.

The severity of downy mildew attack on the cucumber crop varies widely in the different parts of the country and at different seasons, and may also differ greatly from year to year. In order to evolve a means of controlling the disease and increasing the yield under all the conditions likely to obtain, our first concern was therefore to find a treatment of adequate fungicidal efficacy which would not injure the foliage. This treatment should, moreover, fulfil the following two conditions: (1) It should simultaneously control the powdery mildew disease of cucumbers (*Erysiphe cichoracearum* DC.), which is universally present in Palestine in most seasons; and (2) it should be cheap and easy to apply, especially in view of the frequency with which measures for downy mildew control appear to require application in this country.

Surveys of the occurrence of downy mildew of cucumbers in Palestine had left us with the impression, that the development of this disease is less marked where sulphur dusting against powdery mildew has become an established practice. This impression was confirmed by a preliminary sulphuring trial against powdery mildew, when downy mildew appeared unexpectedly on the plots. It was therefore decided to carry out a series of trials in which the comparative effect of sulphur and copper treatment was systematically investigated. The copper sprays were here mostly tested at lower concentrations than in the previous years, in the hope of reducing foliage injury in this way.

Another impression gained in the above-mentioned surveys was that the success of measures for downy mildew control seemed much less certain on plots under overhead irrigation than on those irrigated by furrows. Now overhead irrigation is preferred by many growers because it saves labour and may readily be applied to sloping sites. Elucidation of the rôle played by irrigation in the control of downy mildew was therefore an additional object of these trials, which were conducted in two parallel series, one under overhead and one with furrow irrigation.

The authors wish to thank Mr. E. Krause, Headmaster of Mikve Israel Agricultural School, and Agr. B. Capuler, lecturer for vegetable culture, for permission to use the fields of the school and for help in making arrangements for the trials carried out there. Mr. P. Genazzani and Mr. Z. Avner assisted us in the execution of the trials at Mikve Israel. The execution of the remaining trials has been possible only thanks to the untiring efforts of the members of the various settlements selected for thns work.

II. MATERIALS AND METHODS

A local selection of Damascus cucumbers, called "Beth Alpha", was used in all trials.

The materials tested were:

(1) *Home-made Bordeaux mixture,* prepared from 750 grammes copper sulphate and 500 grammes slaked lime dust in 100 litres solution.

(2) *Perenox,* a proprietary spray based on cuprous oxide, containing not less than 50% metallic copper and 8% chlorine, with a slightly acid reaction; priduced by Messrs. Imperial Chemical Industries, England.

(3) *Floridan,* a proprietary spray containing about 8% of metallic copper in ammoniacal solution, with an alkaline reaction; produced by Messrs. Tapazol, Rishon-le-Tsion, Palestine.

(4) *Perelan,* a proprietary dust based on cuprous oxide and containing 17% metallic copper; produced by Messrs. Imperial Chemical Industries, England.

(5) *Yellow sulphur dust* (flowers of sulphur).

(6) *Yellow sulphur dust* (ground sulphur).

(7) *Gaza sulphur Superfine grade,* containing 90% sulphur, 98% of the dust particles passing sieve no. 300.

(8) *Cita Californian Spray,* a lime-sulphur spray of 30-32° Baumé, produced by Messrs. Chemical Industries, Tel Aviv, Palestine.

(9) *White oil (medium),* stated to contain 80% oil, 50-64% distilling over at 636°F, with 92% unsulphonated residue; produced by Messrs. Shell Company of Palestine.

(10) *Alboleum,* a medium oil the exact composition of which is not known to us; produced by Messrs. Imperial Chemical Industries, England.

In trials nos. 1-5 and no. 8 sprays were applied with knapsack sprayers at 4-8 atmospheres' pressure, in all remaining trials motor sprayers were used and sprays were applied at a pressure of about 20 atmospheres. Dusts were always applied with knapsack dusters.

The incidence of downy and powdery mildews was estimated by the method outlined in our earlier paper.

III. THE TRIALS AND THEIR RESULTS

A. The comparative effect of copper and sulphur materials

1. On plots irrigated by furrows.

Details of the treatments tested and of the results obtained in six trials in which downy mildew development was moderate, severe or very severe, are presented in table no. I. The corresponding data for three further trials where downy mildew developed weakly or not at all appear in table no. II.

TABLE I

The effect of treatments on the incidence of downy and powdery mildew and on the size and distribution of yields in furrow irrigated plots under conditions of s e v e r e downy mildew development

Size of each replicate (m^2)	No. of applications	Treatment	Comparative Incidence (control = 100 %) of*		Size of Yield		% Yield in last third of picking period
			downy mildew	powdery mildew	in kg. per dunum	% (control =100%)	
Trial no. 1, Mikve Israel, 17.4.—30.8.1942							
		1) Control	100(3.2)	100(3.7)	3000	100	2.5
		2) Flowers of sulphur	9	11	4750	158	16.8
		3) Gaza sulphur Superfine grade	7	14	5100	169	15.8
45	12	4) Cita Californian Spray 1.5%	34	62	3050	102	4.7
		5) Perenox 0.33%+ Alboleum 1%	6	29	2950	99	6.5
		6) Alboleum 1%	44	59	2850	95	2.8
		7) Light-medium oil 1%	63	67	3100	103	3.0
		significant differences:			666	22.2	4.46
Trial no. 2, Mikve Israel, 22.3.—15.8.1943							
		1) Control	100(5.4)	100(3.7)	3600	100	1.1
		2) Gaza sulphur Superfine grade	5	12	6000	166	13.1
33	10	3) Cita Californian Spray 1.5%	44	78	4200	117	4.2
		significant differences:			1364	37.9	5.28
*Trial no. 3, Be'er Tuvia, 29.6.—6.9.1943***							
		1) Control	100(4.9)	—	2650	100	3.7
		2) Gaza sulphur Superfine grade	41	—	3250	123	6.8
57	10	3) Cuprous oxide dust***	39	—	2875	109	5.4
		4) Perenox 0.2%	64	—	3075	116	5.7
		5) Floridan 1.5%	49	—	2825	107	8.7
		significant differences:			551	20.8	1.94
Trial no. 4, Usha, 6.9.—24.10.1943							
		1) Control	100(4.0)	100(4.0)	550	100	12.1
		2) Flowers of sulphur	47	25	900	164	28.0
26	8	3) Bordeaux mixt. 0.75%	65	45	675	126	14.7
		4) Perenox 0.25%	60	50	725	133	12.8
		5) Floridan 1.25%	73	63	700	129	16.5
		significant differences:			221	40.2	7.63

* Maximum mark for downy mildew = 8.0, for powdery mildew = 4.0. Figures in brackets indicate the average mark for the 4 control plots.

** In trial no. 3 all treatment plots were first sulphured 4 times, and the treatments indicated were then applied 6 times, beginning with downy mildew appearance.

*** The dust contained 20 parts (by weight) cuprous oxide concentrate and 80 parts kaolin.

TABLE I (continued)

Size of each replicate (m^2)	No. of applications	Treatment	Comparative Incidence (control = 100%) of*		Size of Yield		% Yield in last third of picking period
			downy mildew	powdery mildew	in kg. per dunum	% (control =100%)	
Trial no. 5, Mikve Israel, 4.4.—25.7.1944							
		1) Control	100(5.9)	—	2100	100	9.0
		2) Ground yellow sulphur	15	—	2500	120	26.0
45	7	3) Sulfinette 1.5%	31	—	2230	107	19.3
		4) Perenox 0.25%	40	—	2300	110	15.9
		5) Yellow sulphur, also light-medium oil 1%	11	—	2200	105	27.4
		significant differences:			286	13.6	4.19
Trial no. 6, K'far Glikson, 4.8.—19.10.1944							
		1) Control	100(7.5)	—	2500	100	2.1
42	14	2) Ground yellow sulphur	23	—	2750	111	11.5
		3) Floridan 1.25% alternating with Ground yellow sulphur	12	—	3100	124	15.6
		significant differences:			1188	47.5	5.61

TABLE II

The effect of treatments on the incidence of downy and powdery mildew and on the size and distribution of yields in furrow irrigated plots under conditions of s l i g h t downy mildew development

Size of each replicate (m^2)	No. of applications	Treatment	Comparative Incidence (control = 100%) of*		Size of Yield		% Yield in last third of picking period
			downy mildew	powdery mildew	in kg. per dunum	% (control =100%)	
Trial no. 7, Giv'at Hashlosha, 5.5—8.8.1942							
		1) Control	100(0.7)	100(3.6)	2300	100	13.6
84	9	2) Gaza sulphur Superfine grade	37	69	2700	118	17.9
		3) Perelan	27	91	2200	95	15.0
		significant differences:			382	16.6	4.72
Trial no. 8, Be'er Tuvia, 12.6.—4.9.1942							
		1) Control	100(1.9)	100(4.0)	3250	100	8.7
		2) Gaza sulphur					
52	11	Superfine grade	10	17	4700	142	23.2
		3) Perelan	42	50	3300	102	9.1
		4) Perenox 0.33	10	3	3450	106	13.5
		5) Perenox 0.33%+ Alboleum 1%	26	23	2750	85	20.8
		significant differences:			816	25.1	4.77
Trial no. 9, Sdeh Nahum, 5.9.—30.10.1943							
		1) Control	—	100(3.0)	675	100	
		2) Flowers of sulphur	—	88	675	108	
		3) Cita Californian Spray 1.5%	—	21	750	120	
		significant differences:			159	25.4	

The results summarized in these tables permit the following conclusions concerning the effect of the treatments on mildew development and yield of furrow irrigated cucumbers.

(a) Control of downy mildew. Sulphur dusting proved highly effective in controlling downy mildew even where conditions were conducive to severe outbreaks (trials nos. 2,5,6). All types of sulphur tested, viz. ground sulphur, flowers of sulphur, and Gaza sulphur Superfine grade, gave good results. Sulphur dust equalled, and sometimes surpassed, the action on downy mildew of any of the copper treatments tested (fig. 1).



Fig. 1. Trial no. 1, Mikve Israel
On the left: untreated control row in which all leaves have dried up owing to the attack of cucumber downy mildew.
On the right: row treated with sulphur. The cucumber plants are still well covered with leaves.

Spraying with lime-sulphur spray at 1.5% strengh checked downy mildew development to some extent, but was never as effective as sulphur dusting.

As regards the copper treatments, Perenox (in 5 trials) and Bordeaux mixture (in one trial) again showed themselves as effective as in our earlier trials (7). Bordeaux mixture was used at a strength of 0.75% only. Perenox, on the other hand, was used at concentrations of 0.33%, 0.25%, and 0.20%. At the former two strengths the material always gave satisfactory results; at 0.20% the action appeared to be somewhat weaker, though this was tested in only one trial. Floridan, at 1.25% and 1.50% strength, equalled the action of Perenox. Dusting with Perelan was tested in two trials. In one of these downy mildew development was too weak to permit the performance of the dust to be judged, and in the other trial, where the incidence of downy mildew was slight to moderate, the

action of Perelan was weaker than that of sulphur dust or Perenox. The copper dust tested in trial no.3 (20 parts cuprous oxide concentrate to 80 parts kaolin) proved satisfactory under conditions of severe downy mildew infection.

(b) Control of powdery mildew. The various kinds of sulphur dust showed their efficacy in checking powdery mildew on cucumbers in most of these trials, and in two cases (trials nos.1 and 2) they proved definitely more effective than lime-sulphur sprays, which were used at 1.5% strength. But in trial no.9 the results obtained were exactly the reverse: here flowers of sulphur dust failed almost completely in checking powdery mildew, while lime-sulphur spray checked the disease. We have no satisfactory explanation to offer for this contradiction and can only assume that the strong winds blowing in the Beisan Valley, where this trial was carried out, blew most of the dust off the leaves while the spray deposit persisted.

The controlling effect of Perenox on powdery mildew, as reported in our earlier work, was again confirmed, whereas Perelan dust did not markedly control this disease (trials nos.7 and 8).

(c) Control of aphids. Moderate to severe attacks of aphis (*Aphis gossypii* Glover) developed in trials nos.4 and 8. In addition, observations on the effect of various sprays and dusts, were made in two further trials in which results concerning mildew control were not sufficiently clear to warrant their detailed description in this paper. All these observations agreed in showing that all sulphur dusts reduced the aphid populations unless conditions were extremely favourable for the development of this pest. Copper treatments did not markedly affect the aphids.

(d) Size of yield. In five out of six trials under conditions favourable to downy mildew development, and in two out of three trials with weak downy mildew development, the highest yields were obtained by dusting with one of the sulphur brands. As mentioned above, in two of these trials aphis infestation was marked and its control by sulphur is certain to have raised the yield on the plots under this treatment. In all these trials significant increase in the size of yield above the level of the control plots, were obtained by means of sulphur dust only. In some trials the yield of these plots significantly exceeded that of plots under lime-sulphur or copper treatments. The significant increases in yield secured by sulphur dusting ranged from 18 to 69% of the control yield and from 400 to 2400 kg per dunum (1000 sq.m.) In the only trial in which sulphur failed to increase the yield significantly in spite of severe downy mildew attack on the control plots (trial no.6), the disease appeared so late in the growing season that it did not seem to reduce

the yield markedly on any plot, and the general level of yields was high.

The copper sprays increased yields to various extents, but never significantly. Perelan dust failed to increase the yield. These differences in the yield produced under the copper and sulphur treatments may in some cases (trials nos.4,5,8) be ascribed to superior efficacy of the sulphur dust in checking the two mildews and the aphids. But in trial no.3, and to a lesser extent in trial no. 1, the efficacy of these materials was fairly uniform. In these cases the higher yield obtained by sulphur dusting may probably be taken to indicate the absence of phytotoxic effects of the sulphur on cucumbers, while some such effects would appear to have been caused by the copper treatments.

In all these trials, in which irrigation was normal and the plants were adequately supplied with water, spraying with oil failed to increase the size of yield. On the contrary, in trial no.5 an oil spray applied to a plot subsequently dusted with sulphur prevented the significant yield increase secured on the plots on which sulphur alone was used. Drought conditions, in which an oil spray has effected a consderable increase in yield in an earlier trial (7), did not obtain in the trials outlined above.

(e) Distribution of yield. All the treatments that succeeded in checking downy mildew under conditions favourable to the disease, resulted in marked increase of the percentage of fruit picked during the last third of the picking period, and thus prolonged the duration of the latter. In accordance with its effect on the size of yield, sulphur dust was also in most cases outstanding in its increase of the percentage of late fruit.

In trials no.1,5, and 8 oil sprays were tested in combination with Perenox or on plots which were also sulphured. Our data indicate that the plots sprayed with oil, though giving a lower total yield, produced a higher percentage of late yield than the plots treated with Perenox or sulphur alone. This result confirms previous findings in showing that oil sprays tend to delay fruiting to some extent.

2. On plots under overhead irrigation

Table III presents details of the treatments tested and of the results obtained in three trials where irrigation was by revolving pipes of the "Skinner" system (trials nos.10 and 11) or by sprinklers (trial no. 12).

As apparent from table III, the development of downy mildew was severe in trials nos.10 and 12, but only slight to moderate in trial no.11. Only partial downy mildew control was achieved in all these trials. Where the disease was severe, yields of the control plots

TABLE III

The effect of treatments on the incidence of downy mildew and on the size and distribution of yields in plots under overhead irrigation

Size of each replicate (m^2)	No. of applications	Treatment	Comparative Incidence (control = 100%) of downy mildew	Size of Yield		% Yield in last third of picking period
				in kg. per dunum	% (control = 100%)	
Trial no. 10, Ain Hashofet, 20.7—29.10.1943						
		1) Control	100(5.1)	86	100	28.1
75	8	2) Perenox 0.25%	66	345	401	32.9
		3) Floridan 1%	63	415	480	32.2
		significant differences:		156	180.8	15.34
*Trial no. 11, Ginegar, 25.7.—21.9.1943**						
		1) Control	100(1.8)	710	100	2.9
		2) Gaza sulphur Superfine grade	83	960	136	21.2
66	7—8	3) Bordeaux mixture 0.75%	67	1100	155	33.4
		4) Bordeaux mixture 0.75%+ light-medium oil 1%	56	1230	173	35.4
		significant differences:		261	36.7	6.17
Trial no. 12, Mitspe Hajam, 29.8—23.10.1943						
		1) Control	100(6.8)	33	100	
20	5	2) Flowers of sulphur	81	134	406	
		3) Perenox 0.25%	63	335	1015	
		4) Floridan 1.25%	69	237	718	
		significant differences:		121	367.6	

* In trial no. 11 all plots were sulphured 3 times before appearance of downy mildew. After disease outbreak, plots under treatments 3 and 4 received two applications of copper sprays and 3 more of sulphur dust. while the plots of treatment 2 received 4 more applications of sulphur.

were negligible, and even the best fungicidal treatment could not secure yields sufficient to make the crop pay. In trial no.11, however, where the incidence of downy mildew was weak, even the untreated plots yielded about 750 kg. per dunam, and the increase due to downy mildew control raised the yield to a satisfactory level. These results appear to warrant the following conclusions: Under climatic conditions favourable to downy mildew development, the disease progresses so rapidly on plots under overhead irrigation that none of the treatments tested could check it adequately; under these conditions paying yields of cucumber are hard to obtain. But under climatic conditions less favourable to the disease its control would seem to be feasible even on plots under overhead irrigation.

Trial no.11 was carried out at Ginegar in the Central Valley of Esdraelon, where the water supply is limited and irrigation often not entirely adequate. In view of the favourable results previously obtained under drought conditions with copper oil spray, such a spray was also included in this trial. As indicated in table III, the copper and copper-oil treatments in this trial could only be applied twice. Their effect was nevertheless marked. Bordeaux mixture with light medium oil increased the yield by 18% more than Bordeaux mixture alone, but the difference was not significant. In this trial all treatments greatly increased the percentage of late yield.

A comparison of the effect of sulphur and copper treatments under overhead irrigation was made in trials nos.11 and 12. In both cases the action of sulphur was distinctly weaker, and the resultant yield significantly smaller than that obtained by the best copper treatment. In trial no.11 the percentage of late yield on the sulphured plots was also significantly smaller than on the plots sprayed with Bordeaux mixture.

B. The frequency of fungicidal applications

In our earlier trials on the control of the downy mildew of cucumbers by copper treatments (7), the repetition of applications at frequent intervals was shown to be highly important. In view of our findings that sulphur dust constitutes a suitable means of checking this disease, and considering the fundamental differences in the action of sulphur and copper materials, the question of the optimal frequency of applications for downy mildew control had to be studied anew. This was done in one spring trial, where development of downy mildew was not expected to be severe and treatments were therefore tested at intervals of approximately 8 and 12 days, and in two autumn trials under conditions favourable to the disease, where intervals of 4, 6 and 8 days were tested. In the former trial Gaza sulphur Superfine grade was used, in the latter two trials flowers of sulphur. All these trials were irrigated by furrows.

Table IV presents the results of these trials. In trial no.1, where downy mildew infection was moderate to severe and powdery mildew infection severe, no marked differences in the incidence of these diseases was found to exist on the date of our estimation, 5 weeks before the end of the picking period, between plots sulphured 12 times at intervals of 7-10 days and those sulphured 8 times at intervals of 12-15 days. Nevertheless, the slightly lower incidence of disease on the plots sulphured more frequently was reflected in a yield significantly exceeding that of the plots receiving treatments at longer intervals. The results of both the trials in which downy mildew infection was severe indicate that sulphur applications at 4 days' intervals gave somewhat better disease control than treatments applied once in 6 or 8 days, while there was no difference between these latter two treatments. But the superior effect of sulphuring

at 4 days' intervals failed to be reflected in the yield, and all treatment plots yielded much the same. These results can only be regarded as preliminary in nature and require confirmation.

TABLE IV

The effect of various frequencies of sulphur dusting on the incidence of downy and powdery mildew and on the size and distribution of yield

Size of each replicate (m^2)	No. of applications	Length of interval between successive applications	Comparative Incidence (Control=100%) of*		Size of Yield		% Yield in last third of picking period
			downy mildew	powdery mildew	in kg. per dunum	% (control = 100%)	
Trial no. 1 Mikve Israel, 17.4.—30.8.1942							
	0 (control)	—	100(3.2)	100(3.7)	3000	100	2.5
45	12	7—10 days	7	14	5100	169	15.8
	8	12—15 days	8	19	4300	143	15.9
	significant differences:				666	22.2	4.46
Trial no. 6, K'far Glikson, 4.8.—19.10.1944							
	0 (control)	—	100(7.5)	—	2550	100	2.1
42	14	4 days	23	—	2750	111	11.5
	9	6 days	40	—	2900	116	12.5
	7	8 days	43	—	3300	130	12.0
	significant differences:				1188	47.5	5.61
Trial no. 13, K'far Haroar Hadati, 7.8.—12.10.1944							
	0 (control)	—	100(5.5)	100(1.9)	700	100	
38	13	4 days	27	35	1030	147	
	10	6 days	46	88	1050	150	
	7	8 days	46	83	1000	142	
	significant differences:				210	300	

* see first footnote to table I.

IV. DISCUSSION

A. The effect of sulphur on downy mildews.

Copper dusts and sprays have hitherto been generally accepted as the standard means of checking downy mildew diseases whereever these are troublesome. However, a limited amount of research on the use of sulphur for the control of these diseases has been reported from time to time. The results obtained by YARWOOD (12) have shown that germination tests are unreliable in evaluating the effect of sulphur fungicides on downy mildews. We do not therefore propose to deal with the conflicting evidence on the effect of sulphur on many fungi of this group, as determined in such tests. Taking into account only work on a practical scale, we find that sulphur dusting has proved at least partially successful in controlling downy mildew of vine (*Plasmopara viticola*) (4,9) and of lettuce (*Bremia*

lactucae) (6). Sulphur sprays have been used for controlling such mildews on tobacco (*Peronospora tabacina*) (1) and on onion (*Peronospora destructor*). Conflicting statements have been made concerning the action of sulphur on the fungus causing the downy mildew of cucumbers, with which we are more particularly concerned here. TISDALE (8) reported that in Florida sulphur application failed to control the mildew on cucumbers. On the other hand, field trials in Texas (14) proved that placing sulphur on the ground next to the vines of cantaloupe melons (in order to avoid leaf injury) was effective in checking the downy mildew.

This divergence of results regarding the control of *Peronoplasmopara cubensis* in the field appears to us to be capable of the following interpretation: The level of summer temperature which could affect the action of sulphur, differs very little in Florida and Texas. The chief difference in the climates of these two countries seems to be in the amounts of summer rainfall. According to the data collected in the Yearbook of Agriculture for 1941 of the United States Department of Agriculture, precipitation from June to August averages about 550-600 mm in Florida, but only about 180-200 mm in Texas. It could well be imagined that a higher amount of rainfall during the growing period would adversely affect the action of sulphur dust on the downy mildew. This assumption would be in agreement with the results obtained in Palestine under various types of irrigation. Failure of the sulphur to control the disease in our trials on plots irrigated by overhead pipes may well be considered analogous to the failure of the dust in the summer rains of Florida, while the successful control of the mildew on plots irrigated by furrows parallels the results obtained in Texas. We prefer, at this juncture, to confine ourselves to pointing out the efficacy of sulphur dust on cucumber downy mildew, without venturing an opinion how this effect may be brought about.

B. The action of the copper treatments tested.

Bordeaux mixture 0.75% (0.19% Cu), Perenox 0.25% (0.125% Cu), and Floridan 1-1.5% (0.08-0.12% Cu) revealed satisfactory fungicidal action in controlling cucumber downy mildew. These results confirm the efficacy in the case of this disease of low copper concentrations not only of Bordeaux mixture but also of a spray of the "fixed copper" type, such as Perenox, and of a spray containing copper in a more soluble form, such as Floridan. Our results with copper dusts were so far inconclusive. The addition of white oil to copper sprays failed to affect their fungicidal action in any way.

C. The control of aphids by sulphur dust.

As indicated above, the reduction of the population of aphids (*Aphis gossypii* Glover) on the plots dusted with sulphur was pro-

nounced. Isely and Miner (5) have recently reported on the good action of sulphur on the same species on cotton, and on other aphids. These authors hold that the efficacy of sulphur dusting in aphis control depends on the degree of coverage attained in applying the dust, and on the occurrence of temperatures exceeding a level of about 20°C. Yarwood (13), in observations which were — as those we present here — incidental to work on downy mildew control, found sulphur in California to check aphids on hops; he demonstrated in simple and convincing tests that the action of sulphur on hop aphids depends on the level of temperature, the best kill being obtained at about 31-34°C. In our trials the rate of sulphur application was usually heavy, and temperatures in July-September approximated daily means of 25°C, with mean daily maxima of about 30°C. The action of sulphur on cucumber aphids under these conditions therefore agrees well with the findings of the above authors.

D. Phytotoxic effects.

In the above trials no serious signs of sulphur injury to the leaves was ever observed. This fact is at variance with the findings of Weber (10) in Florida and of Doran (2) in Massachusetts. The reason may lie in the greater resistance of the foliage of the locally selected Damascus cucumbers to such injury.

No leaf scorching was caused by any of the copper sprays tested, but the leaves on most plots subjected to these treatments showed yellowish discolorations of their margins. Comparison of the yields obtained from equally infected plots under treatment with sulphur dust or copper sprays also indicated a certain phytotoxic action of the latter (perhaps with the exception of Floridan) even at the weak concentrations used in these trials.

E. Irrigation and downy mildew development.

A comparison of the results obtained on plots under furrow and overhead irrigation clearly shows the profound effect of the mode of irrigation on the development of downy mildew on cucumbers and on the success of control operations. On furrow irrigated crops fungicidal treatments generally ensured a paying crop even where climatic conditions were most favourable to downy mildew development (as shown by a high final disease rating in the control plots). But on plots under overhead irrigation even the most effective treatments failed to secure adequate yields if climatic conditions favoured the mildew. These results are in agreement with the observations reported by Duvdevani, Reichert and Palti (3), that overhead irrigation is apt to increase the development of downy mildew on cucumbers. Furrow irrigation is therefore definitely to be preferred wherever this disease is serious, and close attention must be paid to the details of such irrigation. Observations in the above trials and on numerous other occasions have proved that the gradient of the furrows must be

absolutely uniform if the accumulation of water in depressions, and consequent development of infection centres, is to be avoided. To prevent the necessity of letting water flow through any one furrow over a period of many hours, furrows should not be longer than about 50 metres, and they should be as wide as practicable.

V. THE PROFITABILITY OF TREATMENTS

The use of sulphur dust for the control of cucumber downy mildew permits the expenses involved in the control of this disease to be reduced much below those hitherto customary. Sulphur dust itself is considerably cheaper than copper sprays. Sulphur dusting is lighter work and is more quickly carried out than spraying. The equipment required for dusting is cheaper than a spraying outfit and is also easier to maintain, an important point on small-holders' farms in Palestine. The total expenses incurred in 7 sulphur applications at the rate of 5 kg. per dunum should not exceed LP. 1.700, including labour and amortisation of dusting equipment. This amount can be covered, at the prices obtained in summer and autumn, by yield increases of only 50-100 kg. per dunum while actual increases of yield due to downy mildew control are usually much larger.

VI. SUMMARY

Thirteen field trials for the control of downy mildew (*Pseudoperonospora cubensis*) and powdery mildew (*Erysiphe cichoracearum*) of cucumbers were carried out in 1942-1944 in various parts of Palestine. In eleven of these trials irrigation was by furrows, while three trials were irrigated through overhead pipes.

On furrow irrigated plots dusting with various brands of sulphur gave excellent control of downy mildew, while spraying with lime-sulphur spray at 1.5% was partly effective. Sulphur dust also controlled powdery mildew, considerably reduced aphid populations, and did not seriously affect the foliage. The yield increase resulting from sulphur dusting reached as much as 60-70% in some trials, the actual weight increase amounting in 1 trial to 2.4 tons per dunum (=1000 sq.m.). Sulphuring also greatly increased the percentage of yield picked during the last third of the picking season, and thus extended the latter markedly.

In the same trials spraying with weak copper sprays, such as Bordeaux mixture 0.75%, Perenox 0.25%, and Floridan 1-1.5%, also showed satisfactory fungicidal action against the downy mildew, but failed to increase yields as much as sulphur dusting.

In the trials under overhead irrigation neither copper nor sulphur treatments succeeded in adequately protecting the crop where development of downy mildew was severe. Only where development of the disease was weaker could economic yields be secured by copper

sprays. In all the trials under this form of irrigation copper sprays were more effective than sulphur dust.

The application of light-medium oil in combination with copper sprays did not affect yields on well-irrigated plots. But in one trial in which the water supply was limited the combined spray gave somewhat better yields than copper spray alone. The oil spray generally increased the percentage of late yield.

Preliminary results are reported of trials designed to determine the frequency with which sulphur dust should be applied for downy mildew control of furrow irrigated plots.

Literature references to the action of sulphur on downy mildews are briefly reviewed. It is suggested that conflicting results obtained in various countries concerning the action of sulphur on cucumber downy mildew may partly be explained by the amount of summer rainfall in these countries, as marked summer rainfall (just like overhead irrigation) appears to render sulphuring less effective.

The conditions under which sulphur dust was found to check aphids on cucumbers are stated to conform with those postulated abroad as conducive to the control of aphids by sulphur.

As overhead irrigation favours downy mildew outbreaks, only furrow irrigation should be used where the disease is serious.

The relatively low cost of sulphur dusting should be easily covered by the resulting yield increase.

REFERENCES

1. Armstrong, G. M., & Sumner, C. B. (1935). Investigations on downy mildew of tobacco. — *Bull. S. Carolina Agr. Exp. Sta.* 303, 23 pp.

2. Doran, W.L. (1933). Downy mildew of cucumbers. — *Massachusetts Agr. Exp. Sta. Bull.* 283, 22 pp.

3. Duvdevani, S., Reichert, I., & Palti, J. (1946). The development of downy and powdery mildew of cucumbers as related to dew and other environmental factors. — *Pal. Journ. Bot., Reh. Ser.*, 5(2): 127-151.

4. Faes, H. (1932). Annual Report for 1931 etc. — *Ann. Agric. de la Suisse* . 33: 153-169.

5. Isely, D., & Miner, F. O. (1946). Sulfur as an aphicide. — *Journ. Econ. Entom.* 39(1): 93-94.

6. Osmun, A. V. (1933). Department of Botany. — *Ann. Rep. Massachus. Agric. Exp. Sta. for* 1932, *Bull.* 293, *pp.* 15-21.

7. Reichert, I., Palti, J., Minz, G., & Kapuler, B. (1944). Trials for the control of downy and powdery mildew of cucumbers. I. On the efficacy of various copper fungicides. — *Pal. Journ. Bot., R. Ser.*, 4:96-116.

8. Tisdale, W. B. (1930). Plant Pathology — *Ann. Rept. Florida Agr. Exp. Sta. for* 1930. pp. 90-107.

9. Trotter, A. (1937). I trattamenti polverulenti contro la Peronospora della Vite. — *Ric. Ossvz. Divulg. fitopat. Campania e Mezzogiorno* (*Portici*) 6, pp. 108-110. 2 pl.

10. Weber, G. F. (1936). Downy mildew of cucurbits. — *Florida Agr. Exp. Sta., Gainesville, Press Bull.* 492.

11. Yarwood, C.E. (1937). Sulphur and rosin as downy mildew fungicides. — *Phytopath.* 27: 931-941.

12. Yarwood, C. E. (1941). Evaluating sulphur fungicides for the control of downy mildews. — *Phytopath.* 31: 865 (*abstr.*)

13. Yarwood, C. E. (1943). Sulphur Dust and hop aphides. — *Journ. Econ. Entom.* 36:641.

14. Plant pathology and physiology. (1930). — *43rd. Ann. Rept. Texas Agr. Exp. Sta.* 1940, *pp.* 56-57.

ON A METHOD OF FIXING AND MEASURING RELATIVE HUMIDITY IN SMALL CLOSED CONTAINERS

By I. WAHL

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot, and Mikve Israel Agricultural School.

The purpose of this work was to examine whether a cheap and suitable method could be found for the determination of the relative humidity prevailing in confined spaces where fungi grow and their spores germinate. Whereas the temperature can be regulated easily in a laboratory equipped with thermostats, the methods used to ensure constant relative humidity at various levels are as a rule complicated and involve marked expenses, especially when large containers are used (6, 13).

I. THE MAINTENANCE OF GIVEN LEVELS OF RELATIVE HUMIDITY

It is easier to determine humidity levels if the growth process of the fungi is studied in small containers. In this case, the desired humidity is maintained by the use of given concentrations of certain chemical solutions. Use is thus made of the fact that solutions of various chemicals, in suitable concentrations, produce specific and constant vapour-pressures. In this respect sulphuric acid has proved of great value (4, 5, 6, 12, 15).

The above mentioned method, however, presents serious disadvantages. First of all, sulphuric acid gives off sulphur trioxide and sulphur dioxide, especially when particles of organic matter fall ino it. These gases may be injurious to the organism under investigation (17). Secondly, the concentration of the acid changes if the water exchange between the solution and the surrounding space assumes marked proportions. These changes in their turn bring about changes in the relative humidity of the atmosphere (6). It may be assumed that the second disadvantage also attaches to the methods where various concentrations of KOH (14), NaCl (3, 7) and various sugars (1, 9) are used.

These shortcomings can be overcome by working with oversaturated solutions of suitable salts (1, 6, 9, 11, 17), provided that the temperature within the container remains constant. If humidity in the surrounding space increases and some more water is added to the solution, the concentration of the latter will yet remain unchanged. This is, of course, due to the fact that a certain amount of the precipitated salt will then pass into solution. If humidity within the surrounding space decreases, the solution will make up for the loss, and a certain amount of salt will be added to the precipitate (17).

We see, therefore, that self-regulation of the level of humidity is assured. The interested reader will find a list of salts together with data of the relative humidities they maintain at given temperatures in the papers by SPENCER (11), OBERMILLER (9), and HOPP (6).

Taking into consideration that diffusion on the surface of the liquid takes place at a very slow rate, and that the desired humidity fills the closed space only after a considerable time, it is desirable to make use of flat, and not high containers (17) and the investigated object is to be placed near the surface of the solution. Where the conditions of the experiment require a larger space, it is necessary to stir the air within the container by fans or aspirators. The two methods to be described here are based on the above mentioned principles (6).

The first method involves the use of two Petri dishes of different size, the smaller one, which is uncovered, being placed within the larger. The solution is on the bottom of the larger dish and the material to be studied is placed on agar on the bottom of the smaller dish. This method is described by HOPP (6). Its advantages lie in its simplicity and cheapness, while it implies very little disturbances in the water exchange. Nevertheless it has the disadvantage that the presence of agar obscures the actual conditions of humidity (1).

In the second method use is made of dry substrates such as glass slides, instead of agar: GUBA (5) and others have worked in this way enclosing the substrate and acid under a bell jar; but in this procedure there is a danger of slow diffusion as the walls of the container are much too high. CLAYTON (1) tried to overcome this difficulty by moving about the containers during the experiment. This method is, however, too expensive and not easy to perform; moreover, the spore-carrying slides are for this purpose fixed in a perpendicular direction and this creates unusual circumstances for germination.

For this reason we have endeavoured to find another method, which, on the one hand, avoids as far as possible the disadvantages we have mentioned above and, on the other hand, entirely suits our purpose. We made use of Petri dishes, as in these the desired humidity is established within a relatively short time, and of dry slides placed in a horizontal position.

This really means a simplification of the method described by HOPP (6). We simplify the method with a substrate of glass, instead of agar, by using only one Petri dish and by working with the upper covers of the Petri dishes serving in place of glass slides.*) The spores lie accordingly in a horizontal position and the germinating tubes develop horizontally. It is thus easy to determine the germina-

*) After completion of the work described here we noted that YARWOOD (16) has also used the covers of Petri dishes for germinating spores.

tion percentage by placing the cover under the objective of the microscope.

Experimental work

Experiment no. 1.

Methods. Ordinary Petri dishes (radius 4.25 cms. and height 1.8 cms.) were used. 3 c.c. of the salt solution were poured into the bottom of the dish, special care being taken that an adequate deposit of salt shall persist in the solution all over the surface of the bottom. The cover was rinsed with chromic acid, 96% alcohol and distilled water, and dried with a clean rag. The dish was then closed and left for 24 hours in order to allow time for diffusion to take place. Then the cover was removed and replaced temporarily by another one. To the underside of the first cover spores were applied by means of a needle or a fine brush. The spores used were those of *Alternaria brassicae*. When transferring the spores, we tried to apply them to the cover free of any agar that might have adhered to them.

After application of the spores, the cover was replaced on the bottom part of the dish, and the spores were thus close to the surface of the solution. After a lapse of 24 hours, we removed the cover bearing the spores and examined their germination without disturbing them in any way. During this examination the lower dish was covered with another cover. This experiment was repeated six times.

Results. Table I shows the results of the germination counts.

TABLE I

Germination of spores of Alternaria brassicae after 24 hours at 20°C at different humidities

*Relative humidity %**)*	*Rate of germination*
In hanging drop-contact	30-35%
100%——over distilled water	35%
98%—K_2SO_4	28-30%
96%—$H_2CrO_4 . 2\ H_2O$	10%
94%—KNO_3	2-3%
92%—K_2HPO_4	Traces

The results presented in table I are in fair agreement with those obtained for *Alternaria brassicae* by Chawdhury (2), who found that 90% represent the minimum level of humidity for germination, and for *Alternaria citri* by Tomkins (14).

To complement this experiment *Alternaria brassicae* spores were also germinated on plain agar in a further experiment.

**) The data in this column are quoted from Spencer (11), with the exception of that referring to H_2CrO_4 which is quoted from Clayton (1) and Obermiller (9).

Experiment no. 2.

METHODS. 1.5 c.c. agar were poured into the inside of a Petri dish cover, and care was taken so that a surface of uniform size was obtained in all the dishes. The average diameter of the agar layer was 2 cm. Relative humidity was stabilized by the aid of saturated solutions of the same salts that were used in the previous experiment. Spores of *Alternaria brassicae* were applied to the agar.

RESULTS. The results observed after 36 hours appear in table II.

TABLE II

Increase of the diameter of agar cultures of Alternaria brassicae after 36 hours at 20°C at various humidities

Relative humidity %	*Diameter of growth made (in cm.)*
100%—over distilled water	0.6×0.6
98%—K_2SO_4	0.2×0.5
96%—H_2CrO_4 .$2H_2O$	0.2×0.5
94%—KNO_3	0.3×0.2
88%—K_2CrO_4	0.2×0.2
87%—KCl	0.2×0.2
84%—KBr	0.2×0.2
81%—$(NH_4)_2$ SO_4	0.2×0.2
79%—NH_4Cl	trace
76%—NaCl	trace

It may be assumed that in this experiment the influence of various levels of relative humidity on the development of the fungus was obscured by the agar to a very considerable extent. The agar evidently gives off moisture which interferes with the levels of the relative air humidity established by aid of the salt solutions. CLAYTON (1) was, therefore, right in taking special precautions to avoid the introduction even of small pieces of agar into his experimental containers. We thus have to conclude that agar is not a suitable culture medium for experiments dealing with the effect of relative humidity on the germination of fungal spores.

II. THE MEASUREMENT OF RELATIVE HUMIDITY

The second problem facing us in the investigation of the influence of the humidity factor on the growth of fungi was to find a suitable method for measuring relative humidity in small closed containers.

A review of the various physical methods employed to determine relative humidity has been given in a paper specially devoted to the problems of the measurement of humidity in closed spaces (8). The measuring instruments described therein fall into three main groups. The first group includes dew-point hygrometers, the chief drawback of which consists in the difficulty of recognizing the first droplets of dew. In the second group, to which the hair hygrometer belongs, the level of relative humidity is indicated by means of linear expansion of hygroscopic bodies; hygrometers of this type are useful

in work not requiring a high degree of accuracy. The third group consists of psychrometers. In order to obtain results with these, it is essential to provide an air current of a speed not less than 2 m/sec. around the wet bulb (8).

In addition to the physical methods for the determination of relative humidity, there are other methods based on the close correspondence between colour and relative humidity in such compounds as cobalt thiocyanate or cobalt chloride. According to SALOMON (10), this method gives satisfactory results if cotton tissue paper is used and suitable corrections are made.

In the course of our work on ecological problems of fungal growth, it was found necessary to devise an instrument which would accurately measure relative humidity in small closed vessels. The dew-point hygrometer is unsuitable for this purpose, for the reasons stated above. The ordinary hair hygrometers at our disposal were found to be too large and not sufficiently sensitive. We therefore devised a psychrometer in which the thermometers were replaced by a thermocouple connected with an accurate millivoltmeter Hartmann and Braun 1447381. The possibility of using a thermocouple to this end has also been hinted at in the above mentioned special publication on humidity measurement (8).

Ordinarily, one end of the thermocouple wire terminates in a needle while the other end terminates in a short rod. The latter is immersed in a fixed temperature medium (e.g. ice water) while temperature readings are being taken. In our experiments, however, a moist cloth was wrapped round the thermocouple rod, thus ensuring evaporation from a sufficiently large surface. The temperature of the constant temperature medium serving for comparison with that of the wet rod was measured by means of the needle. The accuracy of this instrument was checked by measuring the relative humidity in small vessels containing standard saturated salt solutions. The observed humidity was compared to the data given by HOPP (6) and SPENCER (11).

Experimental work

TECHNIQUE. Flat bottles, measuring 5 by 12 by 19 cms. were used. During the experiment the bottles were placed in a horizontal position, so that the solution and precipitate covered the inner side of the largest face of the bottle, measuring 12 by 19 cms., and the distance between the top face and the surface of the solution was 4 cms. Next, we took 4 small, closed jars, each measuring 5 by 5 by 9 cms., which were connected with one another in series by means of glass tubes. Concentrated sulphuric acid was poured into the first jar up to one quarter of its height. The second jar conntained $CaCl_2$ sicc. The remaining two jars were filled up to one third of their height with a saturated solution of a suitable salt, the solution being the same as that used as a standard for determining the level of humidity in the

large bottle. The latter was fitted with a three-hole stopper through which we passed one tube connecting with the jar, another tube leading to an aspirator and the thermocouple rod wrapped in a moist cloth. The surface of the rod was roughly 3/4 cms. above the surface of the solution.

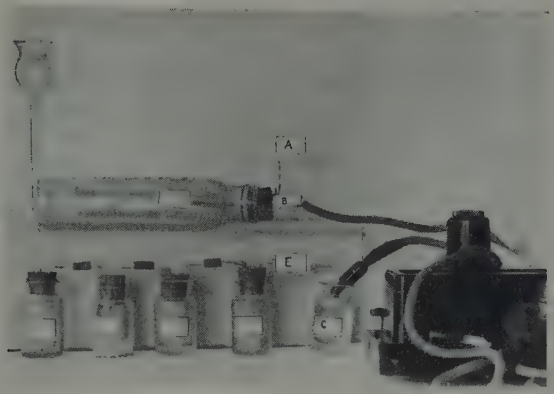


Fig. 1. The measurement of humidity in small, closed spaces. The four small jars contain concentrated sulphuric acid, Ca Cl_2 sicc., and oversaturated solutions of one standard salt. These jars are connected by tube E to the flat flask containing a solution of the same standard salt and the rod (B) of the thermocouple. In the picture this rod has been left uncovered. The big flask is connected to an aspirator by tube A. Jar C is filled with water in which the thermocouple needle is dipped.

The records were all taken at 26°C. Each measurement was repeated four times. The needle was immersed in water, or exposed to the air of a room, temperature of which was constant as shown both by thermocouple and by an accurate decimal thermometer. The thermocouple was occasionally checked in the usual manner, using ice-water, and the deviation of the millivoltmeter was read off. Most records were taken after the aspirator had been working for 5-7 minutes; but in the measurement of high (K_2SO_4, KNO_3) and low ($MgCl_2.6H_2O$) humidities the aspirator sometimes worked for 15 minutes before records were taken.

Results. The results of our measurements, as compared with the data from the standard graphs (6, 11), are presented in table III.

TABLE III

The percentage of relative humidity recorded by a thermocouple device as compared with that indicated by standard graphs

Solution	*Percentage relative humidity*	
	recorded by thermocouple	*read off standard graphs* (6,11)
K_2SO_4	92-93	97
KNO_3	90	92.5
Na_2SO_4	82.4	83.5
NaCl	75-76	76
$K_2CO_3 . 2H_2O$	63-64	65
$MgCl_2.6H_2O$	35-36	33

These measurements indicate that our device gives satisfactory results at a relative humidity range of 60 to 90 percent; outside this range results become less reliable. The chief advantage of this procedure lies in its simplicity and the ease and rapidity of measurement. In order to increase its accuracy, appropriate corrections should be introduced.

SUMMARY

A review is made of the methods used for measuring relative humidity and some improvements are described. Our method consists in fixing relative humidity by the use of oversaturated solutions of various salts in the presence of an excess of the latter and in growing the fungus on the inside of the upper cover of the Petri dish. This arrangement facilitates microscopic examination. In addition, the device used for measuring relative humidity has been improved on the basis of the principle underlying the functioning of psychrometers: but instead of 2 thermometers, one wet and one dry, a thermocouple has been introduced. The procedure followed in carrying out the measurements also differs somewhat from that generally accepted.

The results of experiments in which the accuracy of this measuring device was checked by the use of oversaturated solutions inducing known percentages of relative humidity, have shown the device to be accurate. Some deviations were found to occur at very high (95-98%) and very low humidities (37%).

REFERENCES

1. CLAYTON, C. N. (1942). The Germination of fungous spores in relation to controlled humidity. *Phytopathology* 32: 291-943.

2. CHOWDHURY, S. (1937). Germination of fungal spores in relation to atmospheric humidity — *Indian Journ. Agr. Sci.* 7. 653-657.

3. GOTO, K. (1934). Observations on spore discharge in perfect stage of Sclerotium Rolfsii Sacc. — *Taitkrokn Imp. Univ., Formosa, Contrib. No.* 29.

4. Groom, P., & Panisset, T. (1933). Studies on Penicillium chrysogenum Thom. in relation to temperature and relative humidity of the air. — *Ann. Appl., Biol.* 20 : 633-660.

5. Guba, E. F. (1938). Tomato leaf mold as influenced by environment — *Mass. Agr. Exp. Stat. Bull.* 350.

6. Hopp, H. (1936). Control of atmospheric humidity in cultural studies *Bot. Gaz.* 98 : 25-44.

7. Lesage, P. (1885). Recherches expérimentales sur la germination des spores du Penicillium glaucum — *Ann. Sci. Nat. Bot.* (*Ser.* 8) 1 : 309-322.

8. The measurement of humidity in closed spaces (1933). — *Dept. Sci. & Ind. Res. London, Food Investigation, Spec. Rept. No.* 8, *Rev. Ed., pp.* 70.

9. Obermiller, J. (1924). Die Einstellung von Luft auf bestimmte Trocknungs oder Feuchtungsgrade mit Hilfe von Salzen und ähnlichen Stoffen, und das "relative Trocknungsvermoegen" der Stoffe als Mass ihrer Hygroskopie — *Zeitschr. Physik. Chem.* 109 : 145-164.

10. Salomon, M. E. (1945). The use of cobalt salts as indicators of humidity and moisture. — *Ann. Appl. Biol.* 32 : 75-85.

11. Spencer, H. M. (1926). Laboratory methods for maintaining constant humidity. *Internatl. Critical Tables* 1 : 67-68.

12. Stevens, N. E. (1916). A method for studying the humidity relations of fungi in culture. *Phytopath.* 6 : 428-432.

13. Stoughton, R. H. (1930). Apparatus for growing of plants in a controlled environment. *Ann. Appl. Biol.* 17 : 90-106.

14. Tomkins, R. G. (1930). Studies of the growth of moulds. *I. Proc. Roy. Soc., B.* 105 : 375-401.

15. Wilson, R .E. (1921). Humidity control by means of Sulphuric Acid solutions, with critical compilation of vapor pressure data. *Journ. Indus. and Eng. Chem.* 13 : 326-331.

16. Yarwood, C. E. (1936). The tolerance of Erysiphe polygoni and certain other powdery mildews to low humidity — *Phytopath.* 26(9) : 845-859.

17. Zwoelfer, W. (19932). Methoden zur Regulierung von Temperatur und Luftfeuchtigkeit. *Zeitschr. Angewandte Ent.* 19 : 497-513.

Dedicated to the memory of the great English lichenologist
OTTO VERNON DARBISHIRE.

DIRINA CERATONIAE IN PALESTINE

By

I. REICHERT AND Z. AVISOHAR-HERCHENSON

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

(With plates II and III)

INTRODUCTION

The discovery of *Dirina ceratoniae* in Palestine proved, as shown elsewhere (9), to be very interesting from a phytogeographical aspect. But it seems to be no less interesting from a taxonomic point of view. This lichen belongs to a genus, the systematic position of which is highly controversial. It stands on the border of two different lichen groups: those with roundish apothecia (*Cyclocarpineae*) and those with linear ones (*Graphidinaeae*). The collection of *D. ceratoniae* in Palestine appeared to us to be a good opportunity for taxonomic examination of this lichen. This seemed all the more necessary as taxonomic literature on *Dirina* and on all the lichens with a black hypothecium is scarce. Besides, some of the accepted taxonomic terms, as for instance the "proper margin", are very confuse. It was therefore thought that a detailed morphological study of *Dirina ceratoniae* in the light of the existing literature may contribute to the clarification of the taxonomy of the genus and of the structure of the apothecium of lichens in general.

It is to be much regretted that we were unable to obtain specimens of *D. ceratoniae* from other countries for comparison. In the course of our study we further found that for the exact delimitation of *D. ceratoniae* a taxonomic comparison with the related species *Dirina repanda*, which occurs also in Mediterranean countries, was desirable, but no foreign material was available. In spite of all these limitations we hope that this study may help to clear up some of the above mentioned problems.

IDENTIFICATION

The determination of our lichen is very difficult because of the r o u n d i s h form of its apothecia. On account of this morphological feature one is rather tempted to refer it to the suborder *Cyclocarpinaeae;* this is characterized by ZAHLBRUCKNER (13), on the basis of REINKE's (10) and DARBISHIRE's (2) studies, by its round apothecia, contrasting with the *Graphidineae* in which *Dirina* has so far actually been included, and which are characterised by their l i n e a r apothecia. This was also the reason given by WAINIO (12) for refusing to refer *Dirina* to the *Graphidineae* and for HARMAND (4) to adhere even in 1913 to the system of ACHARIUS (1) to unite *Dirina* with

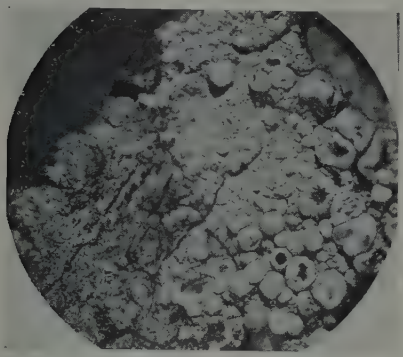


Fig. 1

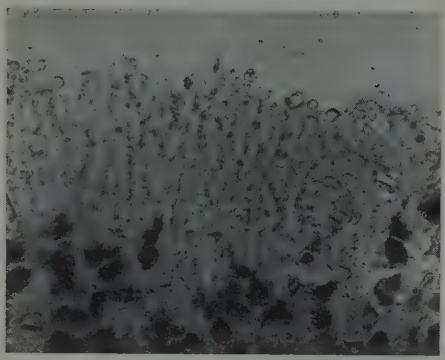


Fig. 2

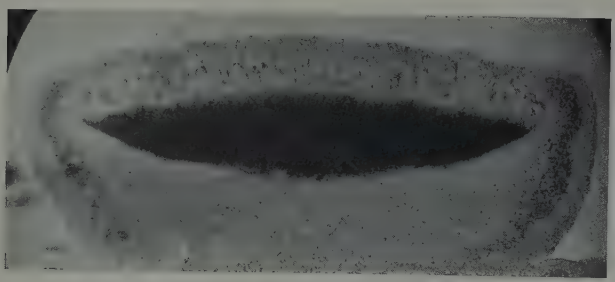


Fig. 3

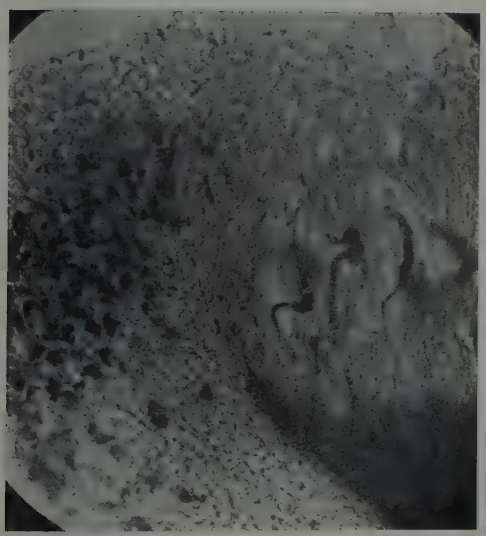


Fig. 4

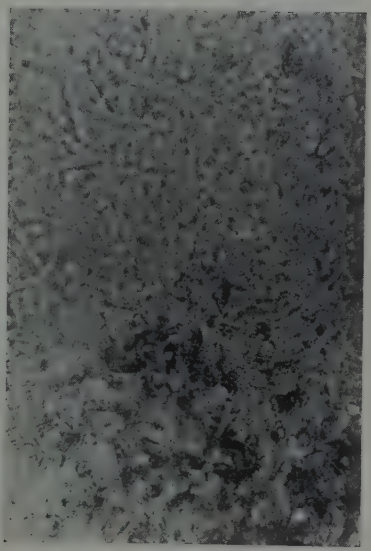


Fig. 5

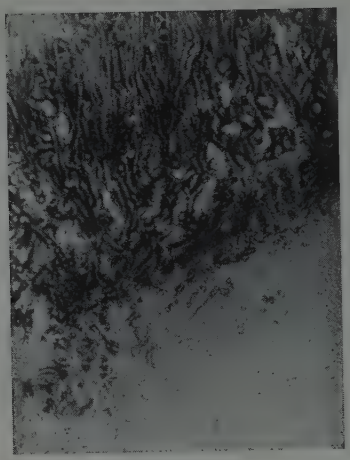


Fig. 6

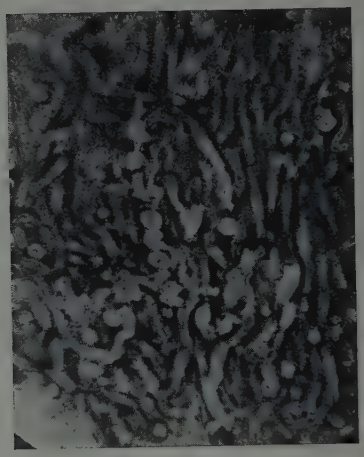


Fig. 7

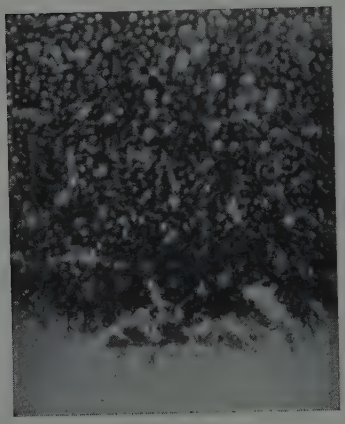


Fig. 8

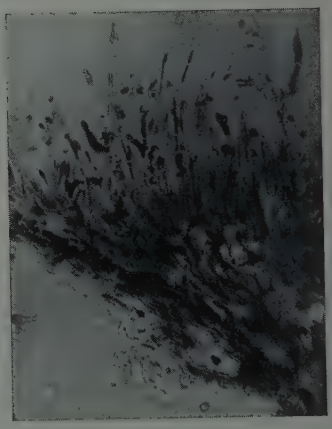


Fig. 9

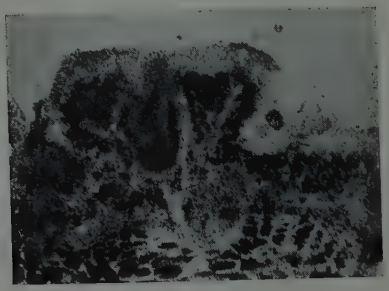


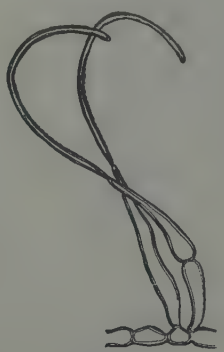
Fig. 10

Lecanora.

All modern lichenologists agree to the following common features of *Dirina*: Gonidia of *Trentepohlia*, a crustaceous, corticate thallus, a thalline margin, and a dark hypothecium. But there are systematic features on which the opinions of lichenologists diverge. Thus for instance the proper exciple or, as DARBISHIRE (2), named it the parathecium, is considered by REINKE (10), DARBISHIRE (2), ZAHLBRUCKNER (13), HARMAND (4) and others (6, 7, 8, 11) as characteristic of the genus *Dirina*. On the other hand LEIGHTON (6) seems to have believed that *Dirina* does not possess a proper exciple, as he describes the apothecia of *Dirina* as "lecanorine", i.e. with a thalline exciple or amphithecium alone. JATTA (5), in defining *Dirina*, emphasizes clearly that it does not possess any proper exciple by saying: "excipulo proprio nullo". All that shows that a new examination of *Dirina* is necessary in order to establish the facts. In the following a detailed description will be given of the *Dirina ceratoniae* specimens found in this country. In the next chapter our findings will be discussed in relation to those of others.



Text-fig. 1.
A single ascus filled with spores, surrounded by paraphyses branching at the top where the epithecium is formed (x 800).



Text-fig. 2.
A drawing of two basidia with their basic cells and their sickleshaped spores (x 2500).

DESCRIPTION*)

Thallus crustaceous, tuberculous, creamy-white, 60—450μ thick. Cortex 20—40μ, composed of an external thin, opaque layer composed of crystals which cover the tops of the hyphae and of a second broader layer composed of erect, septate hyphae which are frequently branching on the whole length, filled with crystals. Hyphae thickened at the top with crystals between them, width of hyphae in the midle 1.5μ—2.25μ, at the top 2.25—3μ, their wall measuring about 0.75μ the length of the hyphal cells is 3—7μ. The gonidial layer of *Trentepohlia* lies closely behind the cortex and is from 25—200μ thick, each gonidium measuring 3—18μ in length, 3—10μ in width, with walls about 0.75μ thick. The medulla is 20—200μ thick and composed of interwoven, septate hyphae, with crystals between them, which measure about 1.5—2.25μ, in diameter and are composed of cells 3.5—7.5μ long with walls about 0.75μ thick. These hyphae pass through the gonidial layer and, when emerging from it, form the cortex. (Plate II, figs. 1, 2; text-fig. 4).

Apothecia roundish with a whitish disc, single or in groups, sessile, slightly prominent (plate II, fig. 1), 450—1750μ in diameter, 160—480μ high, lined on their bottom by a black prosoplectenchymatic hypothecium (plate II, fig. 3, 4) which is 300—1150μ wide and 50—360μ high; its lower part is composed, like the surrounding tissue of the thallus, of hyphae interwoven below, but more and more vertical above, as they approach the paraphyses. They are crossed only by single hyphae traversing them in various direction. A blackish granulate deposit covers the hypothecial hyphae and fills the gaps between them thus giving the whole hypothecium a blackish appearance. The width of the hyphae at their upper part is 1.5—2.25μ and in their lower part 2.25—3μ (plate II, fig. 5; plate III, figs. 6, 7, 8).

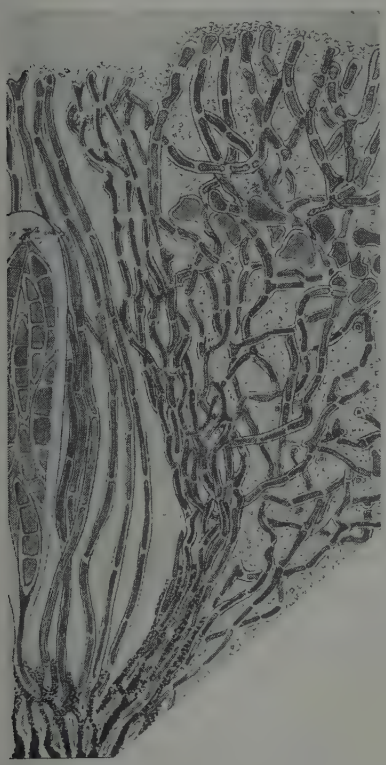
On both sides the apothecium is surrounded by a proper exciple or parathecium which derives from the hypothecium and is composed of hyphae resembling the paraphyses of the hymenium, but differing from them by their shorter cells and by their curvature. The lower part of the parathecium is more or less blackish-brown and the upper part is hyaline. The width of the parathecium is 6—9μ and its height 100—130μ. The width of the paraphysoid hyphae is 1.5—2.25μ, and the length of their cells 4.5—9μ; the wall is about 0.5μ thick (plate II, figs. 3, 4; text-fig. 3).

Hymenium. Epithecium whitish-cream, 40—85μ thick composed of the branching tops of paraphyses. The hymenium is 100—130μ high and 300—1150μ wide. Paraphyses are 100—125μ high, filiform, branching and interweaving at the top only, and frequently covered by crystals; their width is about 1.5—2.25μ at their centre, and up to 3μ at their upper part. The hyphal cells of the paraphyses

*) Where necessary sections were stained with Cotton Blue.

are shorter at the top (2—6μ) than at the centre (10—16μ) with walls about 0.5μ thick. Asci clavate, height (including stalk) 85—120μ, width 12—22μ; the stalk (foot) is 10—36μ high and 2—6μ wide. The lumen of the asci ends at the top at an acute angle)text-fig. 1). Spores are hyaline, fusiform, obtusely pointed, with 3 transversal septa, 20—29μ long and 3.5—5.5μ wide, the cell walls being 0.5—1μ thick (plate II, figs. 3, 4; text-figs. 1, 3).

P y c n i d i a embedded in prominent tubercules, flask-shaped, 120—180μ high, 70—100μ wide (plate III, fig. 10). Basidia derive



Text-fig. 3.

A magnified portion of the parathecium showing the shape of its paraphysoid texture in comparison to the other parts of the thecium. Crystals are seen only in the thalline margin (x 900).



Text-fig. 4.

A portion of the thallus showing the cortex consisting of erect, branching hyphae, the gonidial layer and medulla. In the cortex and medulla crystals are visible (x 900).

from basic cells and bear at their end curved, sickle-shaped, acrogenous, one-celled spores which are 13—16μ long and about 0.5μ wide (text-fig. 4). The basic cells are 2.25μ—5.25μ long and 1.5—2.25μ wide. The basidia are 1—2 septate or non-septate, tapering at the ends, 1—1.5μ wide at the widest part, and 10—13.5μ long (plate III, fig. 10; text-fig. 2).

Reactions: Thallus: KOH macroscopically +, weakly yellowish greenish, microscopically —; $CaCl_2O_2$ +, cortex orange red, I—, HCl+KOH+I: +, lower cortex and medulla blue violet. Thecium: KOH—, I—, HCl+KOH+I: +, KOH+I: +, hymenium (asci + paraphyses) blue.

Localities: The lichen was found on *Quercus calliprinus* and *Laurus nobilis* on Mount Carmel, in April 1942 and March 1946.

DISCUSSION

The character of the apothecium as described above may convey some idea of the possible origin of the hypothecium. We may imagine this process to have taken place in the following way: In the thallus tissue composed of interwoven hyphae, individual hyphae become distinct by assuming a blackish colour (plate II, fig. 5). In longitudinal section these hyphae are seen to be still interwoven at their lower end, resembling the hyphae of the underlying thallus, but the beginning of vertical growth is apparent (plate III, fig. 6). The lateral and transverse hyphae diminish gradually in number towards the hymenium, vertically elongated hyphae increase, and only a few hyphae still transverse the tissue horizontally (plate III, figs. 6,7).

This vertical orientation of hyphal growth in the hypothecium serves as a basis for the subsequent formation of the thecium. That the latter is a direct extension of the hypothecium is particularly evident in longitudinal sections of these two layers (plate II, fig. 4; plate III, fig. 9), showing the paraphyses to link up at their lower end with the vertical hyphae of the hypothecium. These latter hyphae agree entirely with the paraphyses in the size of their lumen and their wall. The black ribbons appearing in the hypothecium are not hyphae but black granular masses filling the spaces between hyphae (plate III, figs. 6, 7).

The above explanation of the formation of the hypothecium, may also throw some light on the problem of the parathecium. As can be seen the parathecium or the proper exciple of *Dirina ceratoniae* is a direct extension of the hypothecium. In their ontogenesis, the hyphae of the parathecium are identical with the paraphyses which, in their turn, have also arisen from the hypothecium. There is no morphological difference between them except that the parathecial hyphae are curved on account of their lateral position, and septa are a little more frequent in their cells. If it were not for a special feature of this hyphal part, which will be discussed below, one would consider

these bundles of paraphysoid hyphae as part of the thecium itself. If we do not consider it as such, this is due firstly to the small morphological differences already mentioned, and secondly — and more particularly — to the blackening of the lower part of these bundles of hyphae. This blackening appears in the same manner (granular excretion and embedding of the hyphae) as in the hypothecium (plate II, fig. 4; plate III, figs. 6, 7). We must therefore consider these parathecial bundles as a real parathecium, and we thus have before us a new type of parathecium. Up to now two types of parathecia have been distinguished according to FINK (3): "either plechtenchymatous in structure or composed of closely interwoven hyphae". The parathecium of *Dirina ceratoniae*, as shown above, is of a hyphal or more accurately of a *paraphysoid* nature.

The formation of the hypothecium in *Dirina ceratoniae*, and probably in other similarly built apothecia, may be imagined to have proceeded in the following way: the hypothecium, as shown above, is composed of thickened hyphae which in their turn are covered by and embedded in excretions which bind this layer together. Whether this layer serves for protection of the thecium or has another function is not clear.

As mentioned above, the top of hypothecial hyphae, i.e. the paraphyses, remain free from encrustation. This may perhaps be due to the sexual process of ascus formation occuring in their midth, whereas the lateral paraphyses which are destined later to form the parathecial layer and are further distant from the centre of sexual reproduction, gradually lose their hyaline colour and separate-filamentous form and blacken in their bottom part.

It is worthy of note that the paraphyses of our *Dirina* when they surpass the level of the thecium or hymenium and form the epithecial layer, branch in all direction and then resemble more or less the structure of the interwoven thallus tissue (plate II, figs. 2, 3, 4; text-fig. 1). It may perhaps be suggested that this reversion of paraphyses to their original habit of growth is due to the fact that this part of the apothecium — the epithecium — lies beyond the orbit and influence of ascus formation, and, like the hypothecium and parathecium, may have a protective function.

The above explanation of the structure of the parathecium of *Dirina ceratoniae* may explain the contradictory descriptions given by various lichenologists. Without doubt DARBISHIRE (2), and REINKE (10) whom he quotes, are right in stating that *Dirina ceratoniae* possesses a parathecium. LEIGHTON (6) and JATTA (5), who deny its occurence probably base their opinion on the fact that the so-called parathecial layer of *Dirina ceratoniae* is composed partly of paraphysoid hyphae and thus does not fit the accepted notions of a proper exciple or parathecium. As shown above, the parathecium of *D. ceratoniae* is really a new type of proper exciple, and therefore *D. ceratoniae* must be considered to posses a valid parathecium.

It must be emphasized that Darbishire's (2) claim that the parathecium of *D. ceratoniae* is hyaline must be amended in so far as in most cases of the locally collected *D. ceratoniae* specimens we examined, the lower parts of the parathecia were blackened.

Another difference between our observations and those of Darbishire (2) and Fink (3) must also be mentioned: The latter describe the hyphae of the cortex as non-septate, but in our specimens they were always found to be septate, as apparent in plate II, fig.2.

Returning to the problem posed at the beginning, concerning the taxonomic position of *Dirina*, it is difficult to understand in the light of our examination of *D. ceratoniae*, why Zahlbrucker (13), basing on Reinke (10) and Darbishire (2), placed the genus in the *Graphidineae*. All the hundreds and more of apothecia from *Laurus* and *Quercus* specimens which we examined, showed a typical cyclocarpous structure. We still think that Waino (12) was justified in placing this genus in the *Cyclocarpineae*. But this question can only be settled finally by an examination of all the species of *Dirina* and perhaps of the related genera.

SUMMARY

A morphological and anatomical description is given of *Dirina ceratoniae* found on Mount Carmel, near Haifa, Palestine.

The histology of the thecium is described in detail with special emphasis on the hypothecium and on the new type of paraphysoid parathecium overlooked by previous students of this lichen.

The results of these examinations are discussed in relation to the observations of other lichenologist and to the taxonomy of the lichen.

REFERENCES

1. Acharius, E. (1810). Lichenographia universalis. *Goettingae.*
2. Darbishire, O. V. (1898). Monographia Rocelleorum. *Stuttgart.*
3. Fink, B. (1935). The lichen flora of the United States. Ann. Arbor.
4. Harmand, J. (1913). Lichens de France. 4, vol. *Paris.*
5. Jatta, A. (1909-11). Lichens. *Societa Botanica Italiana.*
6. Leighton, W. A. (1879). The lichen-flora of Great Britain, Ireland and the Channel Islands. *Shrewsbury.*
7. Migula, W. (1929). Flechten. Kryptogamen-Flora von Deutschland, Deutsch-Oesterreich und der Schweiz. *Berlin.*
8. Mudd, W. (1861). A manual of British lichens. *Darlington.*
9. Reichert, I. The distribution of Dirina ceratoniae. *Pal. Journal of Botany,* Reh. Ser., 5(2): 246-254.
10. Reinke, J. (1894-96). Abhandlungen ueber Flechten. *Jahrbuch fuer wiss. Bot.* 26: 495, 524; 28: 39, 70, 359; 29: 171. Berlin.
11. Smith, A. L. (1926). Monography of Brit. Lichens, vol. 2, edit. 2.
12. Wainio, E. A. (1895-6). Lichenes Antillarum a W. R. ELLIOT collecti. *Journ of Bot.* 34:31-36, 66-72, 100-107, 204-210, 258-266, 292-297.
13. Zahlbruckner, A. (1926) Lichenes. Die natuerlichen Pflanzenfamilien.

EXPLANATION OF PLATES

PLATE II.

1. General view of *Dirina ceratoniae* on *Quercus calliprinus,* showing the thallus and the round apothecia. The apothecia with a black disc have lost their hymenium so that the black hypothecium has become apparent (x3).
2. Cortex and upper part of the gonidial layer. The hyphae are erect with occasional transverse branches (x 700).
3. Section through an apothecium of *D. ceratoniae* showing the black hypothecium, the narrow, hyaline parathecium, blackish at its lower parts, the thalline exciple with gonidial layer, and the thecium with the epithecium (x 100).
4. Part of fig. 3. enlarged. The paraphysoid parathecium and the blackening of its lower parts resembles the hypothecium (x 600).
5. Transverse section of the lower part of the hypothecium at its inception. The interwoven texture of the thallus is seen; some hyphae turn blackish indicating imminent formation of the hypothecium (x 600).

PLATE III.

6. Longitudinal section of the hypothecium. The hyphae of the lower part are still horizontal and interwoven like those in fig. 5, but the upper hyphae gradually assume an erect position (x 400).
7. Enlarged part of Fig. 6, showing granular black masses between and on the hyphae. The rings apparent between the hyphae are transversally cut ends of a few hyphae running in a more or less horizontal direction (x 800).
8. The same portion of the hypothecium as that apparent in Fig. 7., cut transversely. The vertical hyphae are cut across and appear in form of rings. Among them run a few small horizontal hyphae (x 550).
9. A part of the hypothecium showing the passage of its upper hyphae into the paraphyses (x 550).
10. A pycnidium surrounded by gonidia in a prominent tubercle (x 175).

THE DISTRIBUTION OF *DIRINA CERATONIAE**)

By

I. REICHERT

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency, Rehovot

INTRODUCTION

In April 1942 an excursion on Mount Carmel, near Haifa, was arranged by the Botanical Society of Palestine. On this occasion we encountered near the settlement of Beit Oren, at an altitude of about 400 metres above sea-level, a well conserved macchial vegetation of *Quercetum calliprini* with two ancient trees of *Quercus calliprinus*. One of these trees was burning, the fire having probably been caused by Arab shepherds grazing their flocks nearby. The other oak tree was not yet damaged but was also endangered by the fire. On approaching this tree I saw that it was covered, especially on its western side, with a white layer of lichen, which was later identified as *Dirina ceratoniae*.

This lichen has not so far been collected in the eastern Mediterranean, and the destruction by fire of a habitat so interesting and rare from the phytogeographical point of view was therefore highly regrettable. I was therefore gratified when four years later, in March 1946, I again found this lichen on a botanical excursion with Dr. H. Boyko and Dr. H. R. Oppenheimer to the forest reserve called Heitary, on the southern promontory of the Carmel ranges, near Zikhron Ya'aqov. Walking through a degraded macchial vegetation we reached a well-conserved area on a slope with northern exposure, where a *Laurctum nobilis* was growing in a natural, well-developed association. This slope, which was steep and isolated, contrasted in its vegetation from the whole surrounding area. Dr. Boyko remarked that the preservation through the ages of *L. nobilis* in this locality was due to the northern exposure as well as to the small angle of insolation (3) of this slope. I added that this ancient, untouched habitat might certainly harbour the hygrophilous *Dirina*, as it seemed ideally suited for the preservation of a relic such as I assumed the lichen to be. Climbing up the steep gradient to see if any lichens were present, I was very glad to find the northern part of *L. nobilis* trees covered by big white patches of *Dirina ceratoniae*.

In the following we shall outline the biogeographical position of this lichen as viewed in the light of the distribution of this and other species of the genus. We hope that this will be of interest not only to lichenologists but also to general phytogeographers. The taxonomy of the species is being dealt with in a separate paper (22).

* Under the auspices of the Meteorological Research Council, Jerusalem.

As pointed out elsewhere (20, 21), a clear biogeographical picture of an organism is best obtained by analysing it from four aspects, viz. (1) recent distribution; (2) ecological behaviour; (3) origin, and (4) migration. We shall now discuss each of these aspects in turn.

DISTRIBUTION AND HOST RANGE.

The lichen *Dirina ceratoniae* was first collected in Spain on *Ceratonia siliqua* by LAGASCA, who submitted it for determination to ACHARIUS(1). The latter named it *Lecanora ceratoniae*. FRIES(11) mentions as locality of the occurrence of this lichen, besides Spain, also "Gallia meridionalis", and as host plant, besides *Ceratonia*, also *Juniperus phoenicea* though he fails to specify the locality on which it occurred on this host. HARMAND (13) unfortunately added but little to our knowledge of the distribution and host range of the lichen by recording its occurrence "dans le Midi de la France" and "sur l'écorce de plusieurs essences". JATTA (15) is a little more explicit with regard to the distribution of the lichen in Italy and its dependencies, mentioning its occurrence on *Ceratonia* and *Celtis* near Naples, in Etruria, on the islands of Sardinia, Sicilia, Pianose and Melite, and on French Corsica; he does not say anything about the presence or absence of the lichen in the North of Italy. CENGIO-SAMBO (6) quotes the occurrence of the lichen on the island of Rhodes where it was found on *Pistacia mutica*. In Southern Dalmatia a collection of the lichen was made by BRUNNENTHALER on *Olea europaea* and it was determined by ZAHLBRUCKNER (32, 33). STEINER (26) determined as *Dirina ceratoniae* a lichen collected by REICHINGER on *Robinia pseudo-acacia* in Corfu. HARMAND (13) quotes the collection of this lichen by CLAUDEL on *Ficus* in Algeria, and MAHEU and GILBERT (17a) mention its occurrence in Morocco. Finally ZAHLBRUCKNER (34) reports the occurrence of the species in Senegal without mentioning the host. In his Catalogus Lichenum ZAHL-

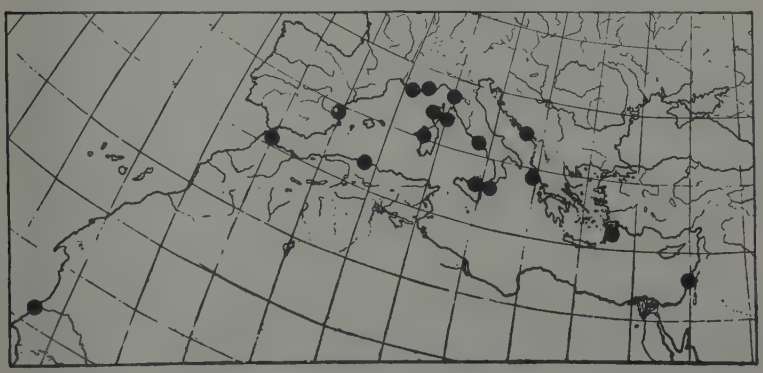


Fig. 1. The geographical distribution of *Dirina ceratoniae*.

BRUCKNER (35) describes the area of the lichen as "Europa meridionalis et regio mediterranea", without giving further details.

Our collection of *D. ceratoniae* in Palestine extends the distribution range of this lichen to the eastern Mediterranean. It has thus been recorded in many of the countries bordering the Mediterranean Sea and may be designated as a Mediterranean Component (Fig. 1).

ECOLOGY

As stated above, the two collections of *Dirina ceratoniae* in Palestine were in humid habitats, on slopes with northern exposure at heights of 300-400 metres above sea level, in localities with 500-600 mm annual rainfall. It must, however, be added that these habitats experience high temperatures (with daily maxima approaching 30°C or even 35°C) in summer, and dry spells (with minimum levels of relative atmospheric humidity of 20-30 percent.) in spring. The lichen must thus be able to tolerate heat and drought to a considerable extent.

Similar ecological conditions seem to prevail whereever *D. ceratoniae* has been found. In Sicily annual mean temperatures average about 18°C and annual rainfall 625 mm. Rainfall in Southern France amounts to about 600-700 mm, with temperatures averaging 14-15°C.

As regards Spain, neither ACHARIUS nor FRIES state what part of the country they are referring to. But as the tree host mentioned is *Ceratonia siliqua*, it may be assumed that the collections were made on the Mediterranean coast of Spain. The amount of rainfall there is about 500 mm, the temperature averages about 17°C; the corresponding figures for Algiers are 700 mm, and 16°C.

The conditions prevailing in all the above habitats indicate that *D. ceratoniae* prefers a humid and moderately warm climate. The lichen may therefore be classed from an ecological point of view as a Humid-Mesothermic Plant Type.

ORIGIN

To elucidate the historico-genetical background of *Dirina ceratoniae* we have to supply the answer to two questions: (1) when did this lichen originate, and (2) where may its origin be supposed to be located. A reply to the first will facilitate an answer to the second question.

Before dealing with the period of origin of the species *D. ceratoniae*, that of the genus *Dirina* as a whole must be considered. The area of distribution of the genus may give us a clue for this purpose. Of the 19 species known, the largest number, no less than 10, occur along the entire length of the Pacific coast of Southern and Central America, and on adjacent islands, two occur in the Mediterranean countries, four in Africa (outside the Mediterranean region) and adjacent islands, two in India, and one in Japan (35). The genus *Dirinastrum*, which is closest to *Dirina* and differs from it only in the colour of its spores, occurs also in Australia (34, 35) (fig. 2).



Fig. 2. The geographical distribution of the known species of the genus *Dirina* (apart from *D. ceratoniae*) and of the related genus *Dirinastrum*.

The occurrence of the various species of *Dirina* has been marked by black dots or the area of their occurrence has been enclosed in a wavy line. The occurrence of species of *Dirinastrum* has been marked by a black circle with spikes.

We know to-day that the distribution of an organism over so large and discontinuous an area is not the result of mere accidental dispersal, but reflects the configuration of continents in ancient times (12, 14, 17, 20, 21, 23, 31). Following either the Drift theory (14, 23, 30, 31) or the Land Bridge theory (2, 24), it may be assumed that the southerly continents (South America, Africa, India and Australia) were at one time linked in one huge continent called by some investigators Gondwana or Gondwanis (24, 31) and by others Holonotis (2). Even according to the Drift theory, especially as interpreted by Du Toit (8), the Gondwana was separated from the northerly Laurasia continent by the ancient Thethys Sea. They were connected only for a short period when the sea temporarily regressed. We may therefore assume that both the northern and the southern shores of the Thethys or Mesogaea (9), extending from Central America to Eastern Asia, harboured various species of *Dirina*. After the drying up of the eastern part of the Thethys in the second half of the Tertiary period, only the species of the western part persisted, i.e.

those of the region including what is now called the Mediterranean and Central America. As we know, two such species, *D. ceratoniae* and *D. repanda,* are now to be found in the Mediterranean region. If other species existed on the border of the eastern Thethys they seem to have perished, but some of them may yet be found in the mountains of Western and Central Asia. The species of *Dirina* occurring in Japan may be a relic of this eastern Thethys distribution.

As by far the largest number of collections of *D. ceratoniae* have been made in the Mediterranean area, we may be led to assume that the species has originated in that region of the western Gondwana that corresponds to that area. If we wish to speculate where in this wide area the species may have originated, we have to bear in mind (a) that the lichen has been found more frequently in the western and central than in the eastern Mediterranean, and (b) that the centre of origin of most species of *Dirina* appears to lie in the west, as apparent by the preponderance of species on the Pacific coast. We are therefore inclined to fix the origin of *D. ceratoriae* in that ancient continent that once included the western Mediterranean or North-west Africa, i.e. the Eastern Atlantis. This would easily link up with the collection of the lichen in Senegal as mentioned by ZAHLBRUCKNER (34).

According to all these considerations the species may be designated from a historico-genetical point of view as an East Atlantisian or West Mesogaean Element.

If we assume that the genus *Dirina* has originated in the ancient Gondwana land, the period of its formation may therefrom be deduced. The majority of geologists supporting either the Drift theory (30, 31) or the Permanence theory (2, 17, 24) consider that the Gondwana existed as a continental entity including Australia only until the Triassic period. Although they may have existed before, the species of *Dirina* may be thought to have established themselves and spread through the continent during that period. We shall therefore not go wrong in assuming that our *D. ceratoniae* also existed at that time, and in designating it from a historico-genetical point of view as an Early Mesozoic Element.

MIGRATION

In ancient times the only continental link with Palestine from the west was that with what is now called North-East Africa, as the northern part of the Mediterranean area was then covered by ancient seas. We therefore have to assume that *D. ceratoniae* reached Palestine from North-west Africa through North-East Africa (Abyssinia and Eritrea) and the Sinai peninsula, together with other tropical and subtropical elements which penetrated into the country. This, as we have tried to demonstrate elsewhere (21), by making use of recent geological studies (17, 19), cannot have taken place before the Upper Oligocene period, as North Africa and Palestine were previously

inundated by the sea. It can likewise not be thought to have occurred later than that period, as the Sinai peninsula then began to assume its desert character. We therefore conclude that, according to its point of departure on its way to Palestine, *D. ceratoniae* may be called a Sudanian or East African Migrant and according to the time in which this migration may be thought to have taken place, it may be called an Oligocenian Migrant.

DISCUSSION

The above ecological characterization of *Dirina ceratoniae* may lead us to discuss critically the conception of "atlantic" or "oceanic elements". As generally known, plants with a West-European distribution have been termed atlantic elements ever since WATSON (29), FLAHAULT (10), BRAUN-BLANQUET (4), and TROLL (28), while some authors according to DEGELIUS (7) described such elements as "pacific". But various authors have used these terms in different senses. WATSON (29) and TROLL (28) use the word "atlantic" for the climatical-ecological definition of plants partial to high atmospheric humidity. BRAUN-BLANQUET (5) employs the same term to cover the genetical aspect as well. STEFFEN (25) restricts its use for geographical definitions, but he employs the term to denote, apart from Western Europe for which it was originally intended, heterogeneous areas such as the Mediterraneis, Sub-Arctis, Eastern Europe or America.

In order to escape such confusion, DEGELIUS (7) has proposed (1) to replace the term "atlantic" by "oceanic"; (2) to employ the term in a climatical-ecological sense exclusively. This definition unfortunately has not come into use, partly owing to the fact that DEGELIUS (7) himself sometimes used the term in a geographical as well as climatical-ecological sense. MATTHEWS (18) has done likewise and has collectively denoted as "oceanic" some areas which, though sharing a certain degree of humidity, are distinct with regard to temperature conditions.

If we were to adopt the above terminology, the genus *Dirina*, with its principal distribution in the Pacific area, would have to be termed an oceanic element, as it everywhere prefers humid habitats. But both the term "oceanic" and the term "element", after being used variously in a geographical, climatical-ecological, and even historical-genetical sense, have become unsuitable for the ecological characterization of a plant. We have suggested elsewhere (20, 21) that for this purpose the term "element" should be replaced by the term "type" as suggested by WATSON (29) and later by TROLL (28) or perhaps even better by "plant type". No geographical or historical-genetical interpretation should be attached to this term, as other terms have been proposed for these purposes. — The term "oceanic" should likewise be replaced by a purely climatical term, for the following three reasons: (a) "Oceanic" will lead to confusion of the region or

climate referred to with the geographical area Oceania. (b) "Oceanic" supplies only one part of a climatical-ecological description, denoting the degree of humidity but giving no indicaton of temperature conditions. This fact has induced various authors, as for instance MATTHEWS (18), to qualify the term oceanic by the addition of various geographical conceptions e.g. "northern oceanic" for low temperature plants and "southern oceanic" for high temperature plants. (c) Abolition of the terms "oceanic" or "atlantic" will render it possible to introduce a term equally applicable to pacific areas. In place of the confusing terms hitherto employed we therefore propose to use two terms, one to characterize humidity relations, the other to denote temperature relations, as is the practice of climatologists (16, 27) in describing various climatical areas. We have accordingly designated *Dirina ceratoniae* as a Humid-Mesothermic Type.

In connection with our study of the origin of *D. ceratoniae*, which we concluded to be an ancient element of the Mediterranean flora, mention may here be made of BRAUN-BLANQUET's (5) researches into the history and genesis of this flora. This author has indicated that, in addition to autochthonic elements, south African, central Asiatic and tropical elements have been concerned in the formation of the Mediterranean flora. Our analysis has shown that additional areas, as for example the Pacific area, may well have to be considered as having given rise to some of the elements of this flora of the Mediterraneis.

In his above research, BRAUN-BLANQUET (5) does not trace the elements he mentions further than the Tertiary epoch. We believe, on the strength of our historico-genetical study, that the origin of *D. ceratoniae* may have to be traced back to the Mesozoic epoch.

We would further like to point out that the term "tropical", as used by BRAUN-BLANQUET to define the elements of the Mediterraneis, is extremely vague. This term gives no indication of the geographical areas of origin, whether this be tropical Asia, Africa or America. Unless coupled with a closer geographical definition, the term "tropical" is an ecological one rather than anything else. This example again demonstrates the confusion caused where no distinction is made between geographical and ecological conceptions.

SUMMARY

The occurrence is recorded of *Dirina ceratoniae* in two localities in Palestine.

According to its geographical distribution this lichen is a Mediterranean Component.

A study of its ecology shows the lichen to be a Humid-Mesothermic Type.

The origin of *D. ceratoniae* is discussed in the light of the distribution of this and other species of the genus. It is concluded

that the lichen may be designated, in respect of the locality of its origin, as an East Atlantisian Element, and in respect of the period of its origin as an Early Mesozoic Element.

According to the probable point of departure of *D. ceratoniae* in its migration, the lichen may be termed an East-African Migrant, while according to the probable period of this migraton it may be called an Oligocenian Migrant.

Critical reference is made to the use in an ecological sense of the term "element", which should be replaced by "type" or "plant type", and of the terms "atlantic" or "oceanic", which should be replaced by double terms describing temperature as well as humidity relationships, e.g. "humid-mesothermic". On the other hand, the term "tropical" should primarily be used as a climatical-ecological conception, unless closer geographical definitions are attached to it.

REFERENCES

1. Acharius, E. (1810). Lichenographia universalis . *Goettingae.*
2. Arldt, Th. (1919). Handbuch der Palaeogeographie, 2 vols. *Leipzig.*
3. Boyko, H. (1945). On forest types of the semi-arid areas at lower latitudes. — *Pal. Journ. Bot., Reh. Ser.,* 5:1-21.
4. Braun-Blanquet, J. (1923). L'origine et le développement des flores dans le Massif Central de France. *Paris.*
5. Braun-Blanquet, J. (1937). Sur l'origine des éléments de la flore mediterranéenne. — *Station Intern. Geobot. et Alpine, Montpellier, Comm. No.* 56.
6. Cengio-Sambo, M. (1927). Licheni di Rodi II. — *Nuovo Giorn. Bot. Ital.* N. S. 34:829-840.
7. Degelius, G. (1935). Das ozeanische Element der Strauch- und Laubflechtenflora von Skandinavien. — *Acta Phytogeographica Suecica,* 7. 411 pp.
8. Du Toit, A. L. (1937). Our wandering continents. *London.*
9. Feinbrun, N. (1939). A monographic study of the genus Bellevalia Lapeyr. — *Pal. Journ. Bot., Jer. Ser.,* 1:336-409.
10. Flahault, Ch. (1901). La flore et la végétation de la France avec une carte de la distribution des végétaux en France. — *in Corte, Introd. à la flore descr. et illustr. de la France, Paris.*
11. Fries, S. (1831). Lichenographia Europaea reformata. *Lundae.*
12. Gerth, H. (1932-35). Geologie Suedamerikas. *Berlin.*
13. Harmand, J. (1913). Lichens de France. *Paris.*
14. Irmscher, E. (1922). Pflanzenverbreitung und Entwicklung der Kontinente. — *Mitt. Inst. Bot. Hamburg vol.* 5.

15. JATTA, A. (1909-1911). Lichenes. in Flora Italica Cryptogama. — *Rocca S. Casciasso.*

16. KOEPPEN, W. (1931). Grundriss der Klimakunde. *Berlin & Leipzig.*

17. KRENKEL, E. (1925). Geologie Africas, I. Teil. *Berlin.*

17a. MAHEU, J., & GILBERT, A. (1925). Deuxième contribution à l'étude des lichens du Maroc. — *Bull. Soc. Bot. de France* 92:558-570.

18. MATTHEWS, J. R. (1937). Geographical relationships of the British flora. — *Journ. of Ecology* 25:1-90.

19. PICARD, L. (1943). Structure and evolution of Palestine. *Jerusalem.*

20. REICHERT, I. (1921). Die Pilze Aegyptens. — *Englers Bot. Jahrbuecher* 56: 598-727.

21. REICHERT, I. (1940). Colus hirudinosus Cav. et Sech. in Palestine and its taxonomic and phytogeographical position. — *Pal. Journ. Bot., Reh. Ser.,* 3:183-208.

22. REICHERT, I., & AVIZOHAR, Z. (1946). Dirina ceratoniae in Palestine. — *Pal. Journ. Bot., Reh. Ser.,* 5(2): 238-246.

23. SCHMID, E. (1946). Afrikanische Florenelements in Europa. — *Ber. Geobot. Forschungsinst. Ruebel in Zuerich f.* 1945:42-61.

24. SEWARD, A. C. (1941). Plant life through the ages. *Cambridge.*

25. STEFFEN, H. (1935). Beitraege zur Begriffsbildung und Umgrenzung einiger Florenelemente Europas. — *Beih. z. Bot. Centralbl. Abt. B* 53:330 404.

26. STEINER, J. (1914). Lichenes in Beitrage zur Kryptogamenflora der Insel Korfu. — *Verh. K.K. Zool. — bot. Ges. Wien, pp.* 184-207.

27. TREWARTHA, G. T. (1943). An introduction to weather and climate. *New York.*

28. TROLL, K. (1925). Ozeanische Zuege im Pflanzenkleid Mitteleuropas. Drygalski Festschrift. *München.*

29. WATSON, H. C. (1835). Remarks on the geographical distribution of British plants etc. *London.*

30. WEGENER, A. (1922). Die Entstehung der Kontinente und Ozeane. *3rd. Ed. Braunschweig.*

31. WULFF, E. V. (1943). An introduction to historical plant geography. *Waltham, U.S.A.*

32. ZAHLBRUCKNER, A. (1915). Lichens, in Beitraege zur Naturgeschichte der Scoglien und kleiner Inseln Sueddalmatiens. *Wien, pp.* 41-62.

33. ZAHLBRUCKNER, A. (1919). Vorarbeiten zu einer Flechtenflora Dalmatiens. — *Oesterr. Bot. Zeitschr.* 68; 148-165.

34. ZAHLBRUCKNER, A. (1926). Lichens, in Die Natuerlichen Pflanzenfamilien, *Leipzig.*

35. ZAHLBRUCKNER, A. (1923-1932). Catalogus lichenum universalis. Vol. III & VIII, *Leipzig.*

NOTES

PRELIMINARY TRIALS FOR THE PREVENTION OF BLOSSOM DROP OF TOMATOES BY HORMONE SPRAY

By I. REICHERT, S. MOELLER and J. PALTI

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

Blossom-drop represents one of the gravest problems of the cultivation of summer tomatoes in Palestine. Part of the blossoms undoubtedly sheds as a result of the attack of various insects, among which the bug *Cyrtopeltis tenuis* appears to be the chief culprit. Nevertheless, the phenomenon seems to be essentially physiological in nature. In an earlier communication, Reichert (Hassadeh 15(6), 1936, Hebrew) concluded that high temperatures in conjunction with low atmospheric humidity are mainly responsible.

In the field trials summarized here we tested the effect on blossom drop of a proprietary *a*-naphthyl-acetic acid spray, Phyomone, produced by Messrs. Imperial Chemical Industries in England. This spray was arbitrarily used at a concentration corresponding to 22 parts per million of the active ingredient. In three of the four trials the Phyomone plots also received normal fungicidal treatments, and were compared with plots receiving only these treatments as well as with plots receiving no treatment at all. In the fourth trial the control without any treatment had to be omitted. The tomatoes were of the Marmande variety and were trained on cordons. There were 4 replicates to each treatment.

The effect of treatments was recorded in several ways, in order to elucidate the method most suitable for future trials.

1) *Counts of labelled inflorescences*: Labels were attached to 20 inflorescences per plot before any blossoms had shed or fruit had set on them, and the number of blossoms per inflorescence were counted. Two further counts, at intervals of 10 days, were then made of the blossoms and fruits, and stalks of blossoms that had shed. The number of blossoms shed was expressed as percentage of the highest number of blossoms, fruits or stalks recorded at any one of the three counts.

2) *Single counts* of inflorescences on which fruit has already set, recording blossoms, fruits, and stalks of blossoms shed.

3) *Yield records.* In one trial both the number and the weight of fruits per plot was recorded, in one trial only weight records could be kept and in 2 trials all weight records were abandoned owing to unequal plant development.

The results of these trials have been summarized in the following table:

The effect of Phyomone spray on blossom drop, fruit set and yield of tomatoes, summer 1944

	Date of record	Control	Phyomone + white oil 1%, and Perenox 0.33%	Perenox 0.33% + white oil 1%	Phyomone and lime-sulphur spray 1.5%	Lime-sulphur spray 1.5%	Significant differences ($P=0.05$)
Trial no. 1, Mikve Israel (Coastal Plain), 12 applications							
% blossom drop							
labelled inflorescences	(5-25.7.44)	77.2	21.5	69.0		69.9	8.75
single counts	25.7.44	57.8	12.0	65.2		56.8	15.75
single counts	6.8.44	82.0	14.1	75.9		68.3	10.72
% fruit set							
labelled inflorescences	5-25.7.44	7.8	6.1	10.7		8.7	
yield							
single counts	6.8.44	4.0	5.3	3.8		6.4	
weight (kg.) per plant		2.25	2.12	2.92		2.77	0.62
in percent.		100	94	130		123	27.7
no. of fruits per plant		28.8	28.5	40.8		39.2	9.06
in percent.		100	99	142		136	31.5
Trial no. 2, Dan (Upper Galilee), 11 applications							
% blossom drop							
labelled inflorescences	4-24.9.44	91.9		88.1	81.2	92.4	7.72
Trial no. 3, Amir (Upper Galilee), 7 applications							
% blossom drop							
labelled inflorescences	17.-30.10.44	34.4			15.1	24.7	7.46
% fruit set							
labelled inflorescences	17.-30.10.44	64.3			84.9	75.8	
yield							
weight (kg.) per plot		197			222	233	34.7
in percent.		100			113	119	17.6
Trial no. 4, Giv'at Haim (Coastal Plain), 6 applications							
% blossom drop							
labelled inflorescences	18.9-						
% of fruit set	12.10.44				45.7	56.1	
labelled inflorescences	18.9-						
	12.10.44				27.6	20.4	

These figures indicate that the percentage of blossom drop was very high in those plots of trials nos. 1 and 2, which were not sprayed with Phyomone, while in trials nos. 3 and 4 blossom drop was moderate. In trial no. 1 the action of Phyomone in reducing blossom drop was outstanding (14-21% drop as compared with 58-82% in the control). In the remaining trials Phyomone reduced blossom drop only by 10-20%, as compared with the control and the plots receiving fungicidal treatments only, but even this limited reduction was significant. The effect on blossom drop of spraying with Perenox and white oil or with lime-sulphur spray, without Phyomone, was negligible in the first two, and slight in the third trial.

The effect of Phyomone spraying on the percentage fruit set could not be determined with accuracy where blossom drop was severe; it was found that under these conditions much larger numbers of inflorescences would have to be examined for this purpose. In the two trials in which the proportion of blossom drop was moderate, the percentage of fruit set in the plots sprayed with Phyomone exceeded that in the control plots (trial no. 3) or in the plots under lime-sulphur treatment (trial no. 4) by one third.

However, this increase in the percentage of fruit set failed to raise the level of yields, where this was recorded. In trial no. 1 yield was even reduced significantly as compared with the plots receiving only fungicidal, but no Phyomone, treatments; this applied to both the number and the weight of fruits per plant.

These somewhat contradictory results probably find their explanation in the heavy charges of Phyomone applied to the tomato plants. Concentrations of 22 p.p.m. active ingredient, especially if applications are repeated 6-12 times at weekly intervals, are very likely to be far in excess of the dose required. This was realized from the outset, but as technical limitations did not permit us to test more than one dosage and as these trials were to indicate primarily if an α-naphthyl acetic acid spray exerts any action at all on blossom drop, the higher dosage was preferred. Of the two methods tested to determine the percentage of blossom drop and fruit set, consecutive counts on inflorescences labelled beforehand appear to give a more accurate picture than single counts. However, where the amount of labour is limited, single counts on larger numbers of inflorescences are preferable to repeated counts on smaller numbers, in order to obtain reliable figures for the percentage of fruit set.

DOWNY MILDEW ON CAULIFLOWER CURDS

By MATILDA CHORIN
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

Downy mildew has long been known to occur in this country on cabbage and cauliflower plants. The leaf injury caused by this disease has never been serious in the field, while it was occasionally severe in seed-beds. However, a more injurious form of this disease is that affecting the curds of cauliflowers, which was first noted in Palestine in 1940.

The disease is apparent especially on plants left in the field after the normal ripening of the head, for purposes of seed growing. The development of these heads is arrested, and on their white curd appear yellowish-brown spots; the spots extend some way down towards the interior of the head, affecting the "flower-stalks" on one or even on all sides. The colour of these spots remains light brown throughout. Black dots of varying sizes appear on the entire area affected, on which elongated depressions become visible. The plants are sometimes simultaneously attacked by black rot (*Xanthomonas campestris*) or *Alternaria* blackening, which cause more rapid deterioration of the head and may mask the primary cause of disease.



Fig. 1. Downy mildew on the flower stalks of cauliflower curd (x 3).

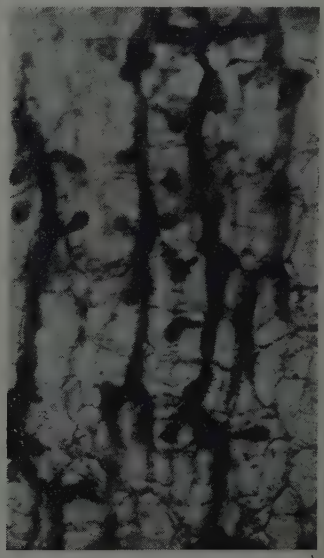


Fig. 2. The hyphae and haustoria of *Peronospora brassicae* in the tissue of cauliflower curds (x 250).

The downy mildew of cauliflower curds is caused by *Peronospora brassicae* Gaeum. The fungus develops richly on the upper, but not on the lower, surface of the top parts of the flower stalks, where it produces a greyish down (fig. 1). The mycelium penetrates the affected tissue and grows between the cells; the hyphae do not penetrate into the cells, but big, pear-shaped, sometimes dichotomously branched haustoria protrude into them (fig. 2).

The downy mildew has so far been found in Palestine in the coastal zone (Ben Shemen, Yagour), in the Western Galilee (Eilon), in the Valley of Esdraelon (Mishmar Haemek, Hephtsibah), and lately in the Jordan Valley (Degania).

Abroad, this form of the disease on cauliflower heads has been reported from the Pacific coast areas of British Columbia (W. Jones, *Sci. Agric.* 24(6) :282-284, 1944), where the losses it causes on cauliflowers grown for seed are stated to be very considerable.

No experimental work on the control of the disease has thus far been carried out in Palestine. The use of copper fungicides is recommended for this purpose abroad.

THE POWDERY MILDEWS OF POTATOES IN PALESTINE

By MATILDA CHORIN

Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

Two powdery mildew diseases affect potatoes in Palestine, one of them of the *Oidium*, and the other of the *Oidiopsis* type. The former has spread over fairly large areas of the country and has at times caused considerable losses of yield. This disease was first recorded in 1927 at Mikve Israel, in the coastal plain, but serious outbreaks have occurred only in more recent years. The *Oidiopsis* type, on the other hand, was first noted only in 1941 and is so far of very limited distribution. The two diseases may appear either separately or sometimes also jointly on the same plants.

Descriptions

The symptoms of the *Oidium* disease are a whitish-grey covering on the leaves and stalks. While present on both sides of the leaves, the powdery cover is more in evidence on their undersides, where it spreads along the principal veins and less frequently also between the latter. On the veins this powdery mildew causes partial or complete browning of the tissue. The whole tissue of affected leaves turns dark brown, wilts, and dries up. — On the leaf-stalks and stalks, the *Oidium* disease causes the appearance of isolated brown

spots, which may coalesce into bigger spots. It is by these brown markings that the disease can readily be recognized in its initial stage.- Affected potato plants dry up progressively, while their leaves persist on the stalks and do not shed.

The *Oidiopsis* disease appears on the underside of leaves in form of a greyish covering of the veins. The veins, and sometimes the tissue between them, turn brown, and the spots are dispersed singly over the lower leaf surface. On the upper side appears a yellow spot corresponding with the area covered by the greyish powder on the lower side of the leaf. Finally, the isolated brown spots coalesce, the midrib turns brown; the yellow spot previously apparent on the upper side likewise turns brown and dry, and the entire leaf browns and dries up.

The main difference in the symptoms of the two powdery mildews of the potato lie thus in the fact that *Oidium* first causes browning of stalks and veins, then a whitish coherent covering of both leaf surfaces, while *Oidiopsis* appears in form of dispersed spots with greyish covering on the underside of leaves.

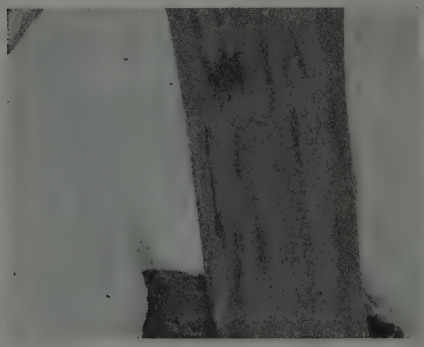


Fig. 1. Potato stalk affected by *Oidium*. Dark dots or streaks are apparent on the brown lesion.

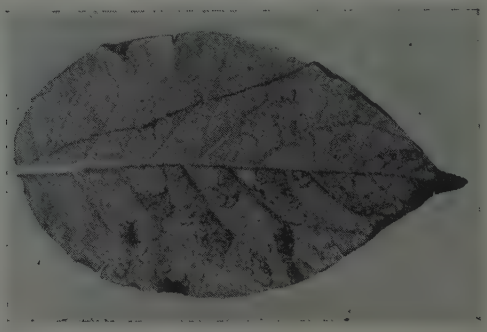


Fig. 2. Underside of potato leaf affected by *Oidiopsis*. The leaf tissue has turned brown.

Distribution

Although first noted in the coastal plain in 1927, the *Oidium* disease first developed in a serious epiphytotic on the southern slopes of the mountains of the Galilee and in the eastern Valley of Esdraelon in November 1941, after two rainless months with frequent khamsins. In the dry spring of 1942 the disease spread in the Jordan Valley, the Valley of Esdraelon, the Beisan Valley, and later on (April-May) in the Upper Galilee. In addition, the disease has been recorded in some localities in the coastal area where relatively dry conditions are known to prevail frequently, viz. at Ben Shemen, Nezle (near Petah Tiqva), and on southerly slopes at K'far Hassidim. In autumn 1942 the onset of rains was early, and rain continued to fall without long interruptions until spring 1943. During this autumn, winter and spring, the *Oidium* did not appear anywhere in this country, while slight symptoms were recorded in the Upper Galilee (K'far Gil'adi) in June 1943. An entirely different position obtained in autumn 1943, when a few days of rain were followed by a series of late khamsin days. The *Oidium* disease then developed profusely on potatoes in the Upper Galilee, in the eastern Valley of Esraelon, and at Meshek Yagur. The geographical and seasonal distribution, as outlined above, indicated that the disease is restricted to conditions of low humidity.

The *Oidiopsis* disease was recorded together with the *Oidium* in the Eastern Valley of Esdraelon (Beit Hashitta) in November 1941, when development of the disease was weak. In December 1946 *Oidiopsis* was again found, this time causing more serious damage, at Beit Haarava at the north end of the Dead Sea.

Outside Palestine, *Oidium* diseases of the potato have so far been reported from France, Germany, Russia, Cyprus, Peru and New Jersey (U.S.A.). No record of *Oidiopis* appears to have yet been made on potatoes abroad, but this disease is known to affect numerous members of the *Solanaceae* in many Mediterranean countries.

SCLEROTIUM BATATICOLA TAUBENHAUS AS CAUSAL AGENT OF A ROT OF SHAMOUTI ORANGES

By F. LITTAUER and J. GUTTER,
Division of Plant Pathology, Agricultural Research Station of the Jewish Agency for Palestine, Rehovot

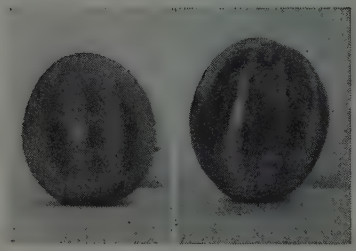
Sclerotium bataticola Taubenhaus was isolated for the first time from a rotting Shamouti orange fruit found in a grove in the vicinity of Lydda, Palestine.

The rot was of light brown colour, similar to that caused by *Diplodia natalensis* Pole-Evans and extended from the buton to the stylar end, along the segments.

According to the measurements of the sclerotia from cultures, their size does not exceed 100 and the fungus appears thus to belong to HAIGH's C group of *Sclerotium bataticola* (Ann. Roy. Bot. Gard. Peradeniya 11 : 213-249).

All the inoculations on Shamouti orange fruits, incubated at 24°C, were successful. 4 days after inoculation a watery spot, several centimeters in diameter, appeared around the inoculation point. During the following days, the decay extended quickly along the segments, finally attacking he whole fruit. The colour of the decayed area, which at the beginning showed a watery appearanec, became brownish (fig. 1) and later black (fig. 2); the black colour being due to numerous minute sclerotia, formed on the surface (fig. 3). Sometimes the albedo and the core were also blackened. The fruit remained pliable. Similar symptoms were obtained in inoculation tests made by R. WEINDLING and P. A. MILLER in California (cited by FAWCETT in "Citrus diseases and their control", McGraw-Hill Book Co., p. 464, 1936).

Sclerotium bataticola from sweet lemon roots, potato tubers, *Cupressus* sp., *Musa* sp., *Arachis hypogaea* and *Persea gratissima*, inoculated in Shamouti oranges, induced rotting similar to the naturally produced rot.-



Figs. 1 and 2.
Shamouti orange 8 days (left) and 14 days (right) after inoculation.

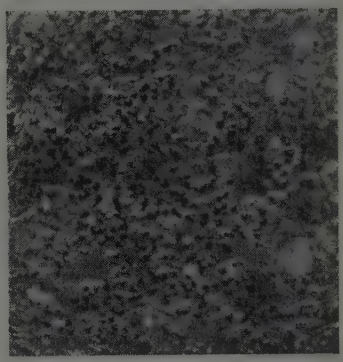


Fig. 3. Sclerotia on the surface of the fruit.

OBITUARY

OLGA FALCK



During the night from the 1st to the 2nd September 1944, Olga Falck passed away in hospital in Moscow at the age of 68. She was then senior assistant at the Botanical Gardens of the Academy of Sciences in the Department of Mycology directed by myself.

Olga Falck began her scientific carrer in May 1904 as scientific assistant in the Institute of Plant-Physiology of Breslau University. From 1906 to 1910 she was my assistant in the mycological laboratory of that University. In 1910 she followed me to the Forest Academy in Hannover-Muenden as my wife and life-long collaborator. For the wedding celebration Olga chose the verse from the Book of Ruth (Chapter II, 16) that runs:

> Whither thou goest, I will go
> And where thou lodgest, I will lodge
> The death part thee and me.

And indeed, in all her life-time, there was nowhere she did not follow me, ever giving the best in our common work. With her help the Institute for Technical Mycology was founded in years of

strenous work, and under her guidance arose a living collection of the fungi important in forestry and in the timber industry.

A mycological garden of this kind was to be instituted on an even larger scale in the Botanical Gardens at Moscow, to cover all the branches of forestry and agriculture.

When Fascism came to power Olga Falck shared her husband's fate and left Germany in spring 1933 after 30 years of joint researches, renouncing for ever facilities specially arranged for her work as well as the circle of her family, collaborators and friends, and her beautiful home among the 100 year old beech-trees.

Thus began the years of wandering, with a temporary stay at Jerusalem where only one of our collaborators, the Indian V.V. Ketkar followed us from Muenden. Thereafter, an appointment to the newly established Forest Research Institute of the Polish State in Warsaw enabled us to continue our studies in forest mycology. In Warsaw Olga Falck devoted all her energy to the renewed collection and culture of the requisite species of fungi in order to be able to continue the comparative study of the fungal flora of trees and timber. Thus important researches could be carried through in our 3½ years of work in Warsaw. Moreover, a small part of earlier researches was published in the journal issued by the Polish Department of Forestry.

When Hitler invaded Poland in autumn 1939, Olga and myself, together with the remaining staff of the Forestry Research Institute, were evacuatel from Warsaw at the last possible moment. Fleeing hastily, we had to leave behind many of the irreplaceable drawings and manuscripts saved from Germany.

In view of an invitation received in 1936 from the Narkomat of Railways in Moscow, we endeavoured to escape to U.S.S.R. Erring for weeks through the country, which was everywhere torn by bombs or already occupied, we reached the frontier near Chelm. Thanks to the generous help of an officer of the Red Army, we were there enabled to board the last lorry returning into the U.S.S.R. where we were at once provided with food, clothing and shelter.

Working at first at Kiev, we were called to Moscow in spring 1940 by the Peoples' Commissar for the timber industry of the U.S.S.R. Here we were both appointed to the staff of the Central Timber Research Institute of the U.S.S.R. "Znimod", in Chimki near Moscow, and were charged with the continuation of our scientific work. Our first task was to follow up the work initiated at Nadworna (Western Carpathians) on the impregnation of newly felled timber (for railway sleepers) by means of water soluble protectants. There the Polish Forestry Administration had instituted an experimental plant and laboratory to explore a new process devised by Falck and these plants had come into the possession of the U.S.S.R. This work could not be concluded owing to the outbreak of war.

Our second task was to investigate the dry-rot that appeared in the museum established in the house of Lenin's birth at Uljanowsk, and to make proposals for its control. This work could still be completed before war broke out.

At the request of the professors of botany in Moscow and Leningrad, Olga and myself were, from the 1st of January 1941, appointed to the staff of the Academy of Sciences in Moscow, where we were placed in charge of a mycological department to be founded in the botanical garden directed by B. A. KELLER. But before the laboratories could be erected and experimental work began, the fascists invaded the U.S.S.R. Thus we were for the third time forced to leave our new work. We were rapidly evacuated to Aschabad the capital of Turkmenia, where a branch of the Academy was established a few years before and Mr. KELLER was nominated president.

After all she had gone through in the preceding years, Olga was no longer equal to these renewed efforts. On our way to Aschabad she collapsed in Tashkent and had to enter a hospital there.

After 5 months of work at Tashkent we continued our way and joined the staff of the Moscow Botanical Gardens evacuated to Aschabad. Here, owing to the unfavourable climatical conditions, Olga began to suffer so severely from angina pectoris, that she could not leave her room. But her love and devotion to science was so strong that she continued to take her full share in the preparation of the manuscript of our work on *Vasomella*. In spring 1944 she was still able to stand up to the strain of our return journey to Moscow, and she was full of hope to continue our common work. But in August 1944 she contracted severe pneumonia which was too much for her weak heart. She succumbed in my arms, and both of us considered ourselves fortunate to have been able to stay and work together in perfect union in spite of the terrible events of the preceding years.

RICHARD and OLGA FALCK studied in 40 years of joint work the fungi living on timber and responsible for its deterioration, with special reference to their diagnostic distinction and prophylactic control. These lifelong monographical studies, were carried out in constant touch with the practice of timber protection, in forests, in timber stores and in affected buildings. Constant connection was also maintained with building engineers and expert advice was given to Courts of Law and to the chemical industry producing the protectants to be tested in this work. The studies comprised the morphology, physiology, and life cycle of the fungi, with Olga taking charge in particular of morphological drawing and of the cultural part of the work.

The *first* comprehensive study, jointly conceived, was "Die *Lenzites* - Faeule des Coniferenholzes" appearing in 1909 as the

third issue of "Hausschwamm-Forschungen" published by Gustav Fischer, Jena.

The *second* study, "Die *Merulius* - Faeule des Bauholzes" appeared in 1912 at the sixth issue of the above.

The *third* study "Die *Coniophora*-Faeule des Nutzholzes", with magnificent drawings especially of sections of the fruiting bodies, of mycelia, and of chord-formation of all species, was ready for print when still in Germany, and was to be published immediately after the study on *Ptychogaster*. However the manuscript had to be left in Warsaw and perished there.

The *fourth* study, "Die *Ptychogaster* - Faeule des Coniferholzes" was already printed by Fischer, Jena, as twelfth issue of the "Hausschwamm-Forschungen" but was no longer permitted to appear in Germany. It was published in 1938 in German and Polish by the Research Institute of the Polish Forestry Administration as 36th issue of series A of "Travaux et Comptes rendues de l'Institut de Recherches des Forêts dominioles Polognes".

The *fifth* study, "Die *Poria* - Faeulen des Nutzholzes", with numerous drawings, remained as an incomplete manuscript in Warsaw and perished there.

The *sixth* study, "Die *Vasomella* - Blaeue des Coniferenholzes" deals with the genuine blue staining of timber caused by the species of *Ceratostomella*. Executed partly in Poland and partly in the U.S.S.R., this study has not yet been published.

The *seventh* study was to deal with timber rots due to *Agaricaceae*. The study on *Lentinus* and *Merulus*-rots had been completed. This material also perished in Warsaw.

The *eightth* and last study, in which Olga's share was particularly significant, dealt with the moulds of timber. Here comparative drawings of the species of *Trichoderma, Penicillium* and *Aspergillus* were presented with coloured pictures of the macroscopical growth of all stages of these fungi on a normal substrate. Hanna Bayer from Hannover-Muenden participated in this work. Unfortunately this great pictorial study has also perished in Warsaw.

The folder with papers on the study of *Vasomella* was all that remained in our possession when the Russian lorry rescued us and brought us to the U.S.S.R.

The obituary notice presented by Professor Falck to the Academy of Sciences in Moscow concludes with the following sentences:

"Olga Isidorowna was for 40 years the faithful companion of my eventful life and work. She was my collaborator, and later co-author of my most important papers, the loving mother and guide of our child.

To her courage and determination to sacrifice without hesitation all comforts of life, and to suffer the hardships of emigration at a mature age for the sake of our common work, we owe our threefold rescue from the fascists from Germany, Poland and Ukraine.

Olga's delicate and skilled hands completed a comprehensive work of microscopical reproductions of fungi drawn from life. The detailed precision of these reproductions ensures their lasting value.

Her profound knowledge of the anatomy, morphology, physiology and biology of the higher fungi renders her death a severe loss to mycology".

In a letter of condolence of the scientific council of the Botanical Gardens of the Academy of Sciences, OLGA FALCK has been awarded the degree of a Doctor of Sciences. This, in the U.S.S.R., represents the highest honour to be awarded to a fellow scientist by the scientific council of the Academy.

RICHARD FALCK

קשיון הבטטה כגורם רקבון בתפו"ז שמוטי

מאת פ. ליטואר וי. גוטר

נמצא שקשיון הבטטה גורם לרקבון פירות תפו"ז שמוטי, הדומה לרקבון של דיפלודיה בצבעו ובהתפשטותו לאורך פלחי הפרי.

אולגה פלק ז"ל

מאת ריכרד פלק

ניתן תאור של עבודת חיי אולגה פלק שהשתתפה בכל עבודותיו של פרופיסור ריכרד פלק, בנסיונות וביחוד בציורים במקצע המיקולוגיה של עצי יער ובנין.

נסיונות ראשונים בהדברת הנשירה של פרחי עגבניה

מאת י. ריכרט, ש. מלר וי. פלטי'

נעשוי 4 נסיונות ריסוס בשדה כדי לבחן את פעולת חומצת » — אצטית — נפטילית בצורת התכשיר „פיומון" על נשירת פרחי העגבניה, במהילה של 22 חלקים למיליון. התוצאות הראו כי בתנאים ידועים עלול ריסוס זה להפחית במידה ניכרת את הנשירה. אולם הגדלת היבול לא נראתה בעקבות עכוב הנשירה.

מחלת הכשותית בתפרחת של הכרובית

מאת מתילדה חורין

בשנת 1940 ראינו בפעם הראשונה השחרת התפרחת בצמחי הכרובית. ביחוד בולט היה הדבר בצמחים שנשארו זמן יותר ארוך בשדה לשם יצירת זרעים. על התפרחת נראתה הצטהבות שירדה לגבעולי הפרחים ועל המקומות הנגועים נראו נקודות שחורות פחות או יותר גדולות — לעתים קרובות נתקפים הצמחים בזמן אחד גם ע"י רקבון שחור הגידים וגם ע"י Alternaria. הם גורמים לרקבון יתר של הצמח ומסתירים את הסיבה האמיתית שגרמה להשחרת הראשים.

מחלת הכשותית נגרמת ע"י הפטריה Peronospora brassicae Gaeum. הפטריה הזאת מתפתחת על החלקים העליונים של גבעולי הכרובית ויוצרת כסוי מלוכלך על חלקי הצמחים שעליהם היא גדלה.

המחלה הזאת נמצאה במקומות מספר בארץ. בחוץ לארץ נמצאה רק במקומות בודדים באמריקה.

הקמחונות של תפוחי-האדמה בארץ

מאת מתילדה חורין

שתי מחלות קמחון תוקפות את תפוחי־האדמה בארץ ישראל: הקמחון והקמחונית. מחלת הקמחון התפתחה בשטח די גדול וגרמה לנזקים רציניים בגידול תפ"א. מחלת הקמחונית תפוצתה מוגבלת וגם הנזק שלה קטן.

הקמחון מופיע על העלים והגבעולים בצורת מכסה לבן־אפור. על צדם התחתון של העלים נראה כסוי קמחי ביחוד לאורך העורקים הראשיים וגורם להחמתם. הכסוי הקמחי מופיע רק לעתים רחוקות על שטח העלה שבין העורקים. הפוך הוא הדבר במחלת הקמחונית: כאן מופיע מכסה אפרפר על העורקים וגם על רקמת העלה. העורקים מחימים הרקמה מחימה והכתמים נראים כאיים בודדים מפוזרים על שטחו התחתון של העלה.

בשני המקרים הופכים העלים חום ומתיבשים.

מחלת הקמחון מופיעה בעיקר באזורים הידועים כיבשים וברטיבות נמוכה.

על קביעת ומדידת לחות יחסית בכלים קטנים וסגורים

מאת ז. ואהל

אחת הבעיות החשובות במחקר האקולוגיה של הפיטריות היא הסדרת (regulation) לחות יחסית קבועה בחלל שבו מגדלים את הפטריה והתקנת מכשיר שיאפשר למדוד ולבקר בעזרתו את דרגות הלחות השונות. בעבודתנו נתנו סקירה על השיטות המקובלות והודענו על השנויים שהכנסנו. אנו קובעים את הלחות היחסית הדרושה בעזרת תמיסות רוויות ביתר (oversaturated) של מלחים מתאימים בנוכחות משקע של אותו המלח. שיטה המקובלת בהרבה מעבדות — אלא שאת הפטריה גדלנו על צדו הפנימי של המכסה העליון אשר בצלחת פטרי. שנוי זה מקל על הבדיקה המיקרוסקופית.

את המכשיר למדידת הלחות היחסית התקנו על יסוד הפרינציפ שעליו בנויים הפסיכרומטרים — אלא שבמקום 2 טרמומטרים, שאחד מהם הוא לח והשני יבש, השתמשנו ב־thermocouple. מהלך המדידות שלנו במכשיר זה הוא שונה במקצת מהדרך המקובלת. התוצאות שנתקבלו מנסיונות בקורת הראו התאמה לנתונים שבטבלאות. הסטיות גדלו במקצת במקרים שמדדנו לחויות גבוהות (95—98%) או נמוכות (33%).

דירינה בארץ־ישראל

מאת י. ריכרט וז. אביזהר־הרשנסון

החזזית דירינה צראטוניה נמצאה בפעם הראשונה בארץ על עצי־אלון ודפנה על הכרמל.

ניתן תיאור מורפולוגי ואנטומי שלם של החזזית. הוכח שהפריטציום (הקיר המקיף את גוף הפרי) הוא טיפוס מיוחד שלא היה ידוע עד עכשיו. ניתן גם תיאור היסטולוגי מפורט של ההיפוטציום (הבסיס של גוף הפרי).

תפוצת הדירינה צרטוניה והתהוותה

מאת י. ריכרט

ניתנה סקירה על התפוצה הגיאוגרפית, האקולוגיה ודברי ימי ההתהוות וההתפשטות בעולם של המין דירינה צרטוניה. הובר שהיא נפוצה בארצות ים התיכון ומהווה טיפוס לח — מסותרמי. מתפוצת כל מיני הסוג המצויים באמרקיה, אפריקה ומזרח אסיה יוצא שמקום המוצא של הסוג הוא המערב הפציפי. כלפי זה המין שנמצא בארץ—מוצאו בארצות ים התיכון ואפשר לסמנו כאלימנט מדיטראני. דרך התפשטותו ונדודיו של מין הארץ היה ממערב אפריקה למזרח־אפריקה ונכנס לארץ־ישראל בתקופת ה„אוליגוצן" כשא"י התרוממה מן האוקיאנוס שכיסה אותה עד אז.

בדיקה מקרוסקופית של העלה הנגוע הראתה הרבה מאוד שרשרות של קונידיות נשאות על נושאים שהתפטיר שלהם זוחל על פני שטח העלה ושולח לתאי העור העליון (אפידרמיס) מציצים (הוסטוריות).

נעשו נסיונות הדבקה והנבטה של מחלת הקמחון על עלי ה־*Dodonaea*. שניהם נתנו תוצאות חיוביות. על הצד העליון של העלים היתה הנביטה וההדבקה יותר חזקה ומהירה מאשר על הצד התחתון של העלים. תוארה המורפולוגיה של חלקי הפטריה השונים ואופן החדירה אל העלים.

נסיונות הדבקה של עלי חרוב בקמחון ה־*Dodonaea* ועלי ה־*Dodonaea* בקמחון החרוב נתנו תוצאות שליליות.

הדברת כמישת תפוחי אדמה

מאת פ. ליטואר, י. פלטי וש. מלר

תוארו שתי מחלות התוקפות את תפוחי האדמה (כמשון ואלטרנריה) ותפוצתן בארץ וניתנו תוצאות נסיונות ההדברה במחלות אלה.

המאמר יופיע במלואו בעברית בקובץ על מחלות ירקות שיצא בקרוב ע"י המחלקה לפתולוגיה.

מחלות החלדון וכתמי השוקולדה בפולים בא"י

מאת י. ריכרט וי. פלטי

ניתנו תאורי שתי מחלות (חלדון וכתמי שוקולדה) התוקפות את צמחי הפול וצוינה תפוצתן בארץ ובחוץ לארץ בהתאם לתנאי האקלים. נמסרו גם תוצאות נסיונות ההדברה שנעשו בארץ.

המאמר במלואו יתפרסם בקרוב בקובץ על גידול מספוא ומחלותיו.

נסיונות שדה בהדברה כשותית וקמחון של מלפפונים:

II. השואת פעילות נחושת וגפרית נגד מחלות

מאת י. ריכרט, י. פלטי וש. מלר

נמסרו תוצאות נסיונות הדברה של נחושת וגפרית במחלת מלפפונים וקביעת ערכו של כל אחד מאמצעי ההדברה האלו.

תוצאות העבודה תתפרסמנה בקרוב בקובץ מיוחד המוקדש למחלות ירקות.

רקבון הנגרם ע"י בקטריות על פרי אבוקדו

מאת צפרירה וולקני

רקבון יבש על פרי אבוקאדו בלתי בשל מגזע Guatemala נמצא בפעם הראשונה בארץ במרץ 1946. הנגע מופיע בצורת רקבון קשה, יבש, שהחל מתפשט מן הפטם על צדו האחד של הפרי וכיסה כשליש משטחו. בחתכים לאורך הפרי, היתה רקמת ה־פרנכימה של החלק הנגוע כהה וקשה יותר מזו של החלק הבריא, ואף הצנורות בחלק הנגוע היו שחורים יותר מאלה אשר בחלק הבריא.

בדיקות היסטולוגיות של החלק הנגוע הראו על מציאותן של בקטריות רבות בתאי הפרנכימה, אך לא בצנורות. תרבות נקיה של בקטריות בודדה מהחלק הנגוע על אגאר מזין ואגאר תפוח־אדמה pH7.2 בטמפרטורה של 25° צלסיוס.

כדי להוכח כי האורגניזמוס הנ"ל הנו גורם המחלה נעשו הדבקות על פירות בריאים בלתי בשלים של אבוקאדו בטמפרטורה של 18°, 25° צלסיוס. ההדבקות נעשו באמצעות דקירות בפטם ושפיכת סוספנסיה של תרבות האורגניזמוס במרק בשר על החלק הדקור. כל הפירות המודבקים הראו סימנים אופיניים של הרקבון הקשה, היבש, ירקרק כהה שתואר בפרי האוריגינלי. האורגינזמוס שבודד מהחלקים הנגועים של הפירות המודבקים מזדהה בתכונותיו עם זה שבודד מהפרי האוריגינלי.

האורגניזמוס הזה צומח יפה על אגאר מזין, מהווה מושבות עגולות בצבע לבן־קרם. זהו מתג לבן קצר 0.6—0.3 על 2.4—1.6 מיקרונים, מתנועע באמצעות שוטטנים מונו—וביפולרים. ג'לטינה מתמוססת, חלב נעשה אלקלי אך לא מתקרש, ניטרטים מוחזרים במקצת או בכלל לא. חומצה בלי גז מתהווה מגלוקוז, סוכרוז, קסילוז, גאלקטוז ובמידה קלה, מגליצרול ומניטול, אך לא מלאקטוז ומאלטוז. הגידול האופטימלי ב־29° — 23 צלסיוס, מקסימלי 35° צלסיוס, מינימלי 6° — 5° צלסיוס. נקודת המות הטרמית בערך ב־50° צלסיוס. פלורסצנציה ירוקה מופיעה בתרבות.

האורגנימוס הנ"ל הוגדר כווריאציה מקומית של *Pseudomonas syringae* הידוע כגורם למחלות הגומה השחורה וצרבון ההדרים, וכ"כ ידוע כגורם מחלה על פרי אבוקאדו.

בעזרת בדיקות היסטולוגיות נתברר כי המחלה מתפשטת מן הפטם ולמטה דרך תאי הפרנכימה. אף כי השחרת הצנורות בחלק הנגוע נגרמה בעטיו של האורגניזמוס לא נמצאו בקטריות בצנורות.

קמחון על עלי *DODONAEA VISCOSA* LINN.

מאת טמירה וולקני

נתן תאור של מחלת קמחון חדשה שהופיעה על עלי שיחי ה־*Dodonaea*. הצומחים בגדר חיה בחצר התחנה לחקר החקלאות ונקראה בשם *Oidium dodonaeae*.

לראשונה מופיעים כסויים לבנים קמחיים על הצד העליון של העלים ועליהם מתבלטים קורים דקים המסתעפים באופן רדיאלי. הכסויים יכולים להיות מצומצמים או לכסות חלקים גדולים של העלה ואפילו את כל העלה ביחוד עם התקדמות העונה בחודש יולי. המקומות האלה הופכים שחרחר־סגלגל ואח"כ חום־שחרחר. העלים שנפגעו ע"י המחלה במידה קשה — מצהיבים ונושרים. היות והעלים התחתונים היו הראשונים לפגיעה הם גם הראשונים לנשירה.

באופן חיצוני לפני עשית התרבות. מובן, הדיפלודיה החיצונית תשלט במקרה זה, בזמן שהדיפלודיה הלטנטית עלולה גם היא להתפתח. המונח דיפלודיה לטנטית, מצד שני, מתאר את בדוד הפטריה מהרקמות לאחר חטוא חצוני (3 שניות בכהל 95%, 60 שניות סובלימט 1000 : 1, ושטיפה במים עקרים). דיפלודיה לטנטית יש להבדיל מהמונח הדבקה לטנטית (latent infection) הרגיל בטרמינולוגיה פיטופתולוגית. הדבקה לטנטית בפירות אומרת, כי הפטריה שחדרה לרקמות הפונדקאי (הפרי) התעכבה בהתפתחות ונשארה רדומה כתפטיר, עד שתנאים ידועים (הבשל, קטיפה, אחסנה) מסיעים להמשך התפתחותה, והעלולים לגרום לרקבון הפרי. „דיפלודיה לטנטית" מתארת בחקירה הנוכחית גם את הנבגים בשקעי העוקץ, שאליהם יכול חומר־חטוא להגיע ולחדור רק בקושי. מציאות זאת של נבגים יכולה להיות חשובה כמקור של התחלת ההדבקה ע"י דיפלודיה.

התרבויות נעשו על אגאר נויטרלי של תפוחי־אדמה + דקסטרוזה 2%, והודגרו בטמפרטורה 25 מ. צ. אזור העוקץ חולק לארבעה חלקים: (1) התך גבעול העוקץ, (2) מצעית, (3) בסיס הפרי, (4) עלי גביע (ראה תמונה מס' 1 בדף 157).

סכום התוצאות

(1) *Diplodia natalensis* נמצאה על העוקץ או בתוכו שבועים לאחר חניטת הפרי (מאי).

(2) במשך התקופה השניה של החקירה, החל בחודש נובמבר, כשהפרי הגיע לגדלו השלם, וגמר עם סוף עונת הקטיף בחודש אפריל, היה שעור הדיפלודיה יותר גדול מאשר בתקופה הראשונה, החלה מחניטת הפרי בחודש מאי עד סוף חודש אוקטובר.

(3) שעור הדיפלודיה הלטנטית הגבוה ביותר נמצא בחדשים מרס ואפריל, לקראת סוף עונת הקטיף.

(4) דיפלודיה נמצאה יותר על עוקצי הפירות מפרדסים זקנים, מאשר על אלה מפרדסים צעירים.

(5) בחלקי העוקץ השונים היה השעור הגדול ביותר של הדיפלודיה הלטנטית בסוף העונה בבסיס הפרי, ובמשך כל העונה היה השעור הגדול ביותר במצעית ובבסיס הפרי, גם יחד.

(6) שעור הדיפלודיה בעוקץ הפירות מעצים גזומים ובלתי־גזומים באותו פרדס לא נבדל בהרבה.

(7) בפירות שאוחסנו במשך שלשה ימים אחרי הקטיף לא נמצא שהדיפלודיה הדביקה את חתך גבעול העוקץ.

(8) שעור הדיפלודיה הלטנטית על עלי גביע נגועים או כמשים, מפירות של פרדס זקן או צעיר, לא עלה על זה של עלי גביע בריאים. אולם כמות הדיפלודיה הכללית על עלי גביע כאלה ועל כל אזורי העוקץ של פירות עם עלי גביע אלה היתה יותר גבוהה מאשר במקרה של עלי־גביע בריאים.

(9) התיבשות עלי הגביע או מלליהם (שפות) עם התקדמות עונת הקטיף (פברואר—מרס) נגרמה בעיקר ע"י הפטריות *Colletotrichum gloeosporioides* ו־*Alternaria sp.*, אף כי גם הדיפלודיה נמצאה לפעמים נוכחת.

(10) על הפרחים נמצאה דיפלודיה רק במקרים בודדים.

(11) הפטריה הגורמת להצטהבות מוקדמת (לפני ההבשל) של פירות אשר הגיעו לגודל נורמלי, ולנשירה הבאה בעקבותיה — לא יכולה להקבע: אולם כל אחת הפטריות: דיפלודיה, קולטוטריכום ואלטרנריה יכולה להיות חשודה כגורם לתופעה זאת.

(12) אפשר להניח שגורם רקבון העוקץ (דיפלודיה) בת"ז שמוטי הם הנבגים היושבים באזור עוקץ הפרי, הנובטים וחודרים לאט לאט עם התקדמות העונה לרקמת הפרי דרך בסיס הפרי.

עתון לבוטניקה

כרך ה׳ חוב׳ ב׳ סדרת רחבות כסלו תש״ז

השפעת הטל וגורמים אחרים על התפתחות הכשותית והקמחון במלפפונים

מאת ש. דובדבני, י. ריכרט, וי. פלטי

השפעת הטל או העדרו על התפתחות הכשותית (פסוידופרונוספורה קובנסיס) במלפפונים שימש נושא לחקירה בנסיונות השדה שבחלק מהם נמנעה התהוות הטל ע״י חפוי בחופת בד בכל לילה וע״כ נתקבלו תוצאות המראות על ערך הטל בהתפתחות המחלה.

העבודה תופיע במלואה בעברית בקובץ על מחלות ירקות שיצא בקרוב ע״י המחלקה לפתלוגיה.

DIPLODIA NATALENSIS — מציאותה על הפרחים, העוקץ ואזור העוקץ בת״ז שמוטי, ויחסה לרקבון העוקץ ונשירת הפרי.

מאת ג. מינץ

רקבון העוקץ של ת״ז שמוטי, כמו ששם המחלה מעיד עליו, מתחיל להתפתח באזור העוקץ של הפרי. רקבון העוקץ של דיפלודיה בת״ז שמוטי מופיע בהתחלת עונת הקטיף ובעיקר בסופה, כשהטמפרטורות השוררות בתקופות אלה מסיעות להתפתחות הפטריה. פירות מפרדסים זקנים נגועים באופן כללי יותר מאשר אלה מפרדסים צעירים (12)*). נסיונות אחסנה בטמפרטורות של $18—20^0C$ הראו, שרקבון העוקץ מתפתח בפירות במשך כל עונת הקטיף (15, 14, 13). לכן היה אפשר להניח שהפטריה נמצאת כנראה בפרי או עליו במשך כל העונה, אולם גורמת לרקבון רק כשהטמפרטורות נעשות נוחות להתפתחותה. מחקירות במעבדה על אופן ההדבקה אפשר היה ללמד, שמעורר הרקבון עלול לחדור לחלקים השונים של העוקץ, אפילו אם הם אינם פצועים, אולם איננו יכול לחדור לקליפת הפרי הבלתי פצועה (16).

גם בחקירות אחרות הניחו או הוכיחו חוקרים שונים (2, 8, 18, 19, 21, 22, 23) את מציאות הפטריה בפרי לפני הקטיפה.

העובדות וההסתכלויות האלה הניעו אותנו להניח שאזור עוקץ הפרי (העוקץ ובסיס הפרי) מאכסן את מעורר הרקבון. בחקירה זו השתדלנו, בעזרת תרבויות מחלקי העוקץ השונים, במשך כל העונה, לקבוע: (1) את מציאות הדיפלודיה, הן השטחית־חיצונית והן הרדומה (latent), בעוקץ השמוטי בכל תקופת התפתחותו, מהחניטה עד ההבשל, (2) באיזה חלקים של העוקץ נמצאת הפטריה.

בשביל הבחירות נשתמש במונח „דיפלודיה כללית" ו„דיפלודיה רדומה" לתאור הבא: המונח דיפלודיה כללית מתאר, כי הפטריה בודדה מחומר שלא חוטא

*) המספרים בסוגרים מתיחסים לרשימת הספרות בטקסט האנגלי.

YAKHIN

The AGRICULTURAL CONTRACTORS CO-OPERATIVE ASSOCIATION LTD.

Creation of New Settlements on the Basis of Plantations & Mixed Farming



YAKHIN, CANNING COMPANY, Ltd.

Jams • Marmelades • Preserves



Picking, Packing, and Export of Citrus Fruits

HEAD OFFICE:

5, LEVONTIN STREET, TEL-AVIV

P.O.B. 332, Tel. 4365

HAMASHBIR HAMERKAZI

PALESTINE COOPERATIVE WHOLESALE SOCIETY LTD.

Head Office:
Tel Aviv, Hamashbir Building, Salameh Rd., P.O.B. 130,
Phone 6011-16.

Branches:
Haifa, P.O.Box 295, Phone 4271, Jerusalem, P.O.Box 438,
Phone 3854.

SALES DEPARTMENTS:
GROCERIES-FEEDING STUFFS / GRAINS & CEREALS-SEEDS / CHEMICALS-FERTILIZERS / AGRICULTURAL MACHINERY-TOOLS & IMPLEMENTS / DAIRY EQUIPMENT-REFRIGERATION / IRRIGATION EQUIPMENT-PUMPS / INDUSTRIAL EQUIPMENT / ENGINEERING SUPPLIES OF EVERY DESCRIPTION / FISHING AND FISH-BREEDING EQUIPMENT / BUILDING MATERIALS-FUEL & LUBRICATING OILS / TEXTILES-FOOT WEAR ETC. / STATIONERY & WRITING MATERIALS / HOUSEHOLD & KITCHEN UTENSILS.

INDUSTRIAL ENTERPRISES:
"Shemen" Ltd., Hamgaper Ltd., Palestine Portland Cement Works Ltd., Hatzamar Ltd., Min'al Ltd., Hamashbir Mill (Flour & Fodder Mill), Hakhayal Ltd., Seed Cleaning Plant (Cleaning & Selection of specially grown seeds).

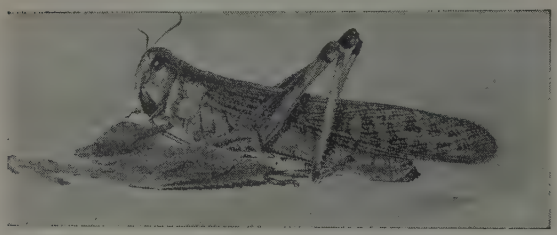
Some of the above Enterprises are operated jointly with other Companies.

AGRICULTURAL MACHINERY & IMPLEMENTS MANUFACTURED IN AGRICULTURAL SETTLEMENTS.

AFFILIATIONS:
HAMASHBIR HAMERKAZI
(Finances & Investments) Co. Ltd.
CONSUMERS' CO-OPERATIONS FUND Ltd.
HAMASHBIR-LAZARCHAN LIMITED

THE LOCUST

threatens the Agriculture of hte Middle East



'AGROCIDE' 7

a **'GAMMEXANE'** product specially made for the preparation of locust baits
destroys the locust and saves the crops

The governments of all countries of the Middle East protect their agricultural economy by using huge quantities of *'Agrocide' 7*, as it is harmless to man and beast and deadly to the locust

'AGROCIDE' *7* is only one of a series of "Agrocide" products for the protection of crops from pests.

'Agrocide' products contain

'GAMMEXANE'

the potent insecticide evolved in Britain by
IMPERIAL CHEMICAL INDUSTRIES,
(London, England)
represented in
Palestine, Transjordan, Syria, the Lebanon, Iraq and Cyprus

by

Imperial Chemical Industries (Levant) Ltd.

SHELL

FRUIT  **SPRAYS**

FOR THE **CONTROL** of INSECT PESTS ON CITRUS
AND DECIDUOUS FRUIT TREES, VEGETABLES,
ORNAMENTAL PLANTS ETC.

FOR **STIMULATION** of DECIDUOUS FRUIT TREES.

Obtainable at the main town offices of SHELL CO. as well as at SHELL agents all over the country.

FOR TECHNICAL INFORMATION PLEASE APPLY
TO THE FRUITSPRAY DEPARTMENT OF

THE SHELL COMPANY of PALESTINE Ltd.

1, Tel-Aviv Road **J A F F A** **Tel. Nos. 4501-3**

AGRARIA SEED GROWERS LTD.

HAIFA, 26 IBN SIRA ST.

P. O. B. 1103 **'PHONE 3051**

GROWERS AND EXPORTERS

OF

VEGETABLE AND FLOWER SEEDS AND FLOWER BULBS

HIGH GERMINATION PURITY OF STRAIN
GROWING ON CONTRACT

J. GREEN & Co. (PALESTINE) Ltd.

PATENT MEDICINES
PHARM. CHEMICALS
SURGIC. DRESSINGS
AND INSTRUMENTS
LABORATORY AND
HOSPITAL SUPPLIES
PHOTO ARTICLES
MICROSCOPES
INDUSTRIAL CHEMICALS.

FUNGICIDES and
INSECTICIDES, FERTILIZERS, CONCENTRATED POULTRY
FOOD, CATTLE &
SHEEP DIPS
GENERAL
COMMISSION

HEAD OFFICE FOR PALESTINE:
TEL-AVIV, 6 Bet Hashoava Lane, P.O.B. 10 — Telephone 4492/3
HAIFA Branch: Herzl St., P.O.B. 65 — Tel. 610
JERUSALEM Branch: Bezalel St., P.O.B., 378 — Tel. 2782
Head Office for Egypt: CAIRO, P.O.B. 600 — Tel. 59948/3
ALEXANDRIA Branch: P.O.B. 1867 — Tel. 6065/2

TNUVA

תנובת המרכזת החקלאית בארץ ישראל

Central Marketing Institution
of Agricultural Co-operative
Societies in Palestine

Head Office:
61, Herzl Str., Tel-Aviv
P. O. B. 265, Tel. 2126

"SHUK HAKLAI"

AGRICULTURAL MARKETING & SUPPLYING CO. LTD.

43, Wolfson Street, Tel Aviv
P.O.B. 2018 Tel. 2307

●

Marketing of vegetables, fruits, poultry, eggs, honey and all other agricultural produce.

Supply of poultry and cattle fodder, seeds, fertilizers, plant protection products

Government and Army Contractors for distribution, cultivation and supply of potatoes.

TAPAZOL
CHEMICAL WORKS

P.O.B. 1531,

TEL-AVIV

◆

Manufacturers of plant protection products

For the control of plant diseases:

CASPAN, FLORIDAN

For the control of plant pests:

SAMBAR, TAPAZOL, ANTEX

דפוס מ. שהם

תל־אביב, רחוב פין 6

טלפון 2239

ת. ד. 576

מקבל כל מיני
עבודות משרדיות
עתונים, ספרים וכו'.

◆

Place your orders with

M. Shoham's Press

6, Finn St., Tel-Aviv

Telephone 2239

P. O. B. 576

עתון לבוטניקה

מופיע בשתי סדרות

א. סדרת רחובות:

יוצאת לאור ע"י ה. ר. אופנהיימר וי. ריכרט מהתחנה לחקר החקלאות, רחובות, א"י. לפי תכניתנו כל כרך בסדרה זו יכיל 2 חוברות (200—300 עמודים) שתופענה משך שנה ככל האפשר.

ב. סדרת ירושלים:

יוצאת לאור ע"י חבר העובדים של המחלקה לבוטניקה באוניברסיטה העברית בירושלים. לפי התכנית כל כרך בסדרה זו יכיל 4 חוברות (300—400 עמודים) שתופענה משך שנה ככל האפשר.

את דמי החתימה יש לשלם למפרע ע"י שק או המחאת דואר. מחיר החתימה הוא:

2.000 לא"י לכרך, בעד שתי הסדרות

1.250 לא"י לכרך, בעד סדרת ירושלים בלבד

0.900 לא"י לכרך בעד סדרת רחובות בלבד.

בסכומים אלו נכללים גם דמי המשלוח.

את דמי החתימה ואת המכתבים הנוגעים בעניני המערכת יש לשלח לפי הכתובות הבאות:

לסדרת ירושלים: עתון לבוטניקה, ת.ד. 620, ירושלים.

לסדרת רחובות: עתון לבוטניקה, ת.ד. 15, רחובות.

במכתבים הנוגעים בשתי הסדרות אפשר לפנות לכל אחת מהכתובות הנ"ל.

את הכרכים הראשונים של סדרת רחובות אפשר להשיג במחירים אלו:

כרכים א', ב' וג' — 0.750 לא"י כל אחד

כרך ד' — 0.900 לא"י.

דפוס ב. שהם, תל-אביב, רח' פין 6, טל. 2239

סדרת רחבות כרך ה', חוב' ב'

כסלו תש"ז

עתון לבוטניקה

סדרת רחבות

(לפנים רשימות לבוטניקה ומדעי הטבעות)

יוצא לאור על ידי

ה. ר. אופנהיימר וי. ריכרט

מהתחנה לחקר החקלאות, רחבות

מזכיר המערכת:

י. פלטי

רחבות